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ARTERIOVENOUS ANEURYSMS OF THE SCALP AND FACE

WALTER E DANDY, M D

BALTIMORE

ARTERIOVENOUS aneurysms in the integument may occur anywhere but are more common in the head than over the remainder of the body, and most of these are in the scalp. They are not common, perhaps between 200 and 300 cases have been reported. Elkin (1924)¹ described a case from Cushing's clinic and noted that this was the only case of its kind that Cushing had seen in his entire experience up to that time in over 35,000 patients admitted to hospitals. Nine additional cases are reported, 1 of these was from Dr. Blalock's clinic and is added, with his permission.

Heine (1869)² collected the first series of cases of arteriovenous aneurysms occurring in the head, 60 in all, but he questioned the diagnosis in 15. In 46 cases the aneurysms were in the scalp (including twelve back of the ear), in 13 cases they were in the face and in 1 case on the tongue. The first cases in his collection were reported by Pellebon (1810), Walther (1823), Dupuytren (1828), Brodie (1829),³ Mussey (1830),⁴ Graefe (1832) and Breschat (1834). Heine ascribed the origin of most of these tumors to congenital nevi or cavernous angiomas that had been present since birth or had at least been observed soon after birth. From these, the vascular radiations gradually spread and enlarged during the years. A minority of cirroid aneurysms had no such antecedent lesions but were known to have followed trauma and were presumably related thereto. Virchow was a dominant influence in Heine's interpretation of this lesion as being congenital. There can be no doubt that this view is correct.

Korte (1880)⁵ added 26 cases and considered his publication a continuation of Heine's excellent report. He too concluded that most

1 Elkin, D. C. Cirroid Aneurysm of the Scalp, *Ann Surg* **80** 332, 1924.

2 Heine, C. Ueber Angioma arteriole racemosum aus Kopfes und dessen Behandlung. *Prag Wrtlschr* **3** 1, 1869.

3 Brodie, B. C. An Account of An Aneurysm by Anastomosis of the Forehead. *Tr Med-Chir Soc* **15** 177, 1829.

4 Mussey, R. D. Aneurysmal Tumors upon the Ear, Treated by Ligation of Both Carotids. *Am J M Sc* **26** 333, 1853.

5 Korte, W. Beitrag zur Lehre vom Angioma arteriale racemosum. *Deutsche Ztschr f Chir* **13** 24, 1880.

I have found in the literature only 2 other examples of this type of aneurysm. Both of these were reported by Brock and Dyke in a series of 8 cases of arteriovenous aneurysms of the brain. One of the patients (their case 5) was the same patient that is reported on as case 9 in this series by my colleagues and me, their report was made before the patient came here for operation, and they, of course, could not know of the remarkable intracranial aneurysm that was also present. Their case 4 is identical in every respect with our cases 4, 5, 6, 7 and 8. They commented on the enlarged posterior branches (bilateral) of the middle meningeal artery, and since the patient had a left homonymous hemianopsia they assumed that the enlarged middle meningeal artery contributed the arterial component of an arteriovenous aneurysm that continued into the visual pathways in the brain. The patient also had the same bilateral pulsating aneurysms in the occipital region of the scalp. From the position of these masses in the occipital region on each side, they inferred that the aneurysms were connected with the occipital arteries. However, in the light of the demonstrations of the meningeal connections in our cases, there can hardly be a doubt that their origin was from the middle meningeal arteries and was part of the intracranial aneurysm.

Curiously, in all 5 cases of homonymous hemianopsia the defect of vision has been to the right, the lesion thus being placed in the left cerebral hemisphere. There would appear to be no rational anatomic explanation for this seemingly consistent localization of the aneurysm to the left side of the brain, excluding the right hemisphere. Since the hemianopsia in the case reported by Brock and Dyke was to the left, it is now clear that either hemisphere may be involved in the aneurysm. Needless to add, it would appear to be only a lucky chance that both hemispheres are not invaded, since both meningeal arteries so commonly participate in the dorsal and the extracranial aneurysms.

REPORT OF CASES

CASE 1—Arteriovenous aneurysm of eyelids. A robust man, aged 37 years, entered the hospital because of a large, disfiguring growth in both upper and lower eyelids of the left side (fig 1 *A* and *B*). He was positive that there had been no swelling or vascular abnormality before he had been struck over the left eye by a steel cable, five years before. The eye was then swollen shut for several days and the lids were discolored, but all the effects subsided. Two months later a small swelling was observed in the left upper eyelid on the inner side, its growth had been progressive. Two years later (three years ago) a similar swelling appeared in the left lower lid, and it too progressed. The swellings were soft and throbbing, but the patient heard no noises. Up to the time of admission, the swelling had been lacerated eight or ten times, following each there was profuse bleeding, and the blood spurted as when an artery is cut.

Examination showed large red swellings of both lids on the left. The eyeball was completely covered, and only laterally was there any indication of a palpebral orifice. The swellings pulsated strongly and synchronous with the radial pulse.

The tumor could be collapsed under a compressing finger, but the pulsation had to be overcome to do it. Especially large vessels stood out at the inner side of the swelling on the left upper lid, which was at the maximum part of the tumor and doubtless was nearest the point of origin of the arteriovenous fistula. Pressure on the common carotid artery stopped the pulsations completely and made the volume of the mass shrink perceptibly. The veins over the left side of the forehead stood out fairly prominently and were tortuous, they ran vertically toward the hair line. A thrill could be felt over both swellings but not over the veins of the forehead.

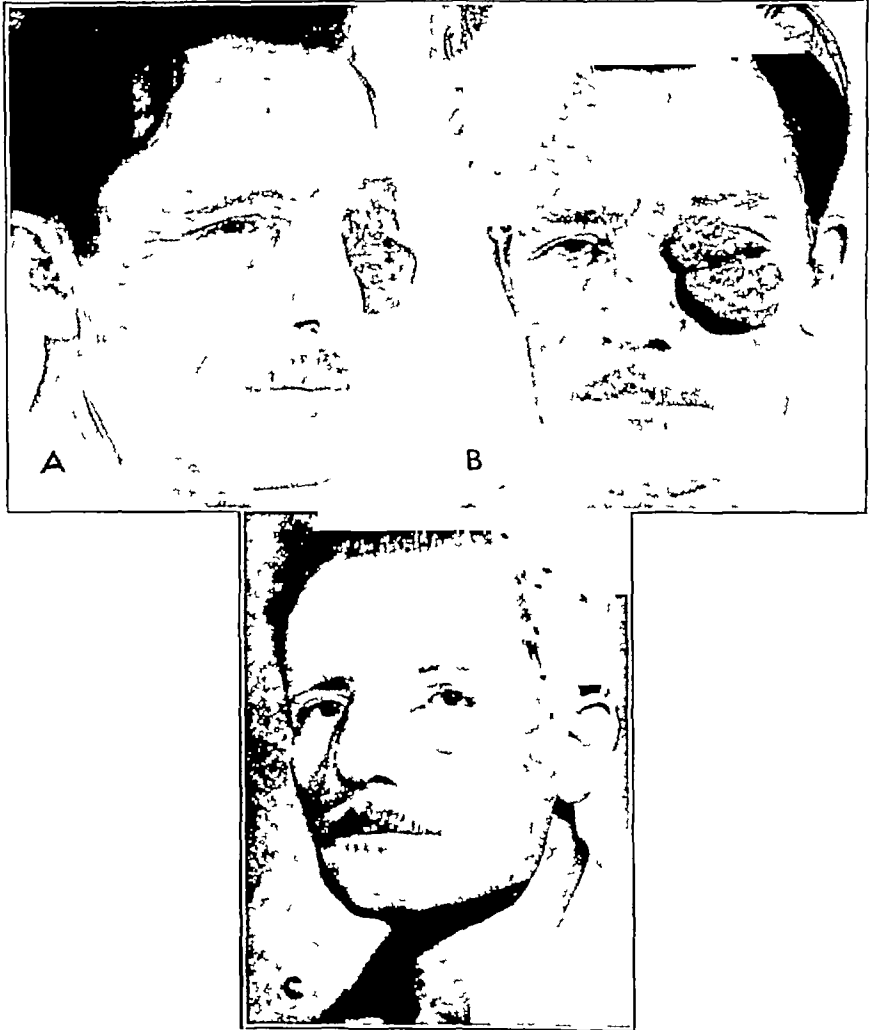


Fig 1 (case 1)—*A* and *B*, photographs of patient with the arteriovenous aneurysm in the eyelids. *C*, same patient one year later. The lower lid was largely destroyed in dissecting the aneurysm, and a flap of skin from the forehead was used by Dr. Staige Davis to replace the lower lid.

The conjunctiva (left) was injected, and the eyeball pulsated and protruded 6 mm. The vision in the left eye was 20/50 and in the right eye 20/20. Examination of the fundus of the eye was noncontributory, the veins were not tortuous or engorged. The visual field was normal. The pupil reacted normally. There was no bruit audible over the head.

prevent sleep. Recently there had been a throbbing sensation in both ears, synchronous with the heartbeats, her hearing was unaffected. She had had occasional convulsions. She was again pregnant, for the eighth time.

Examination showed a large mass of vessels in the midline of the scalp, back of the center, from this, huge, tortuous and nodular vascular trunks radiated in all directions (fig 3 *A*). One large collection passed forward to the bridge of

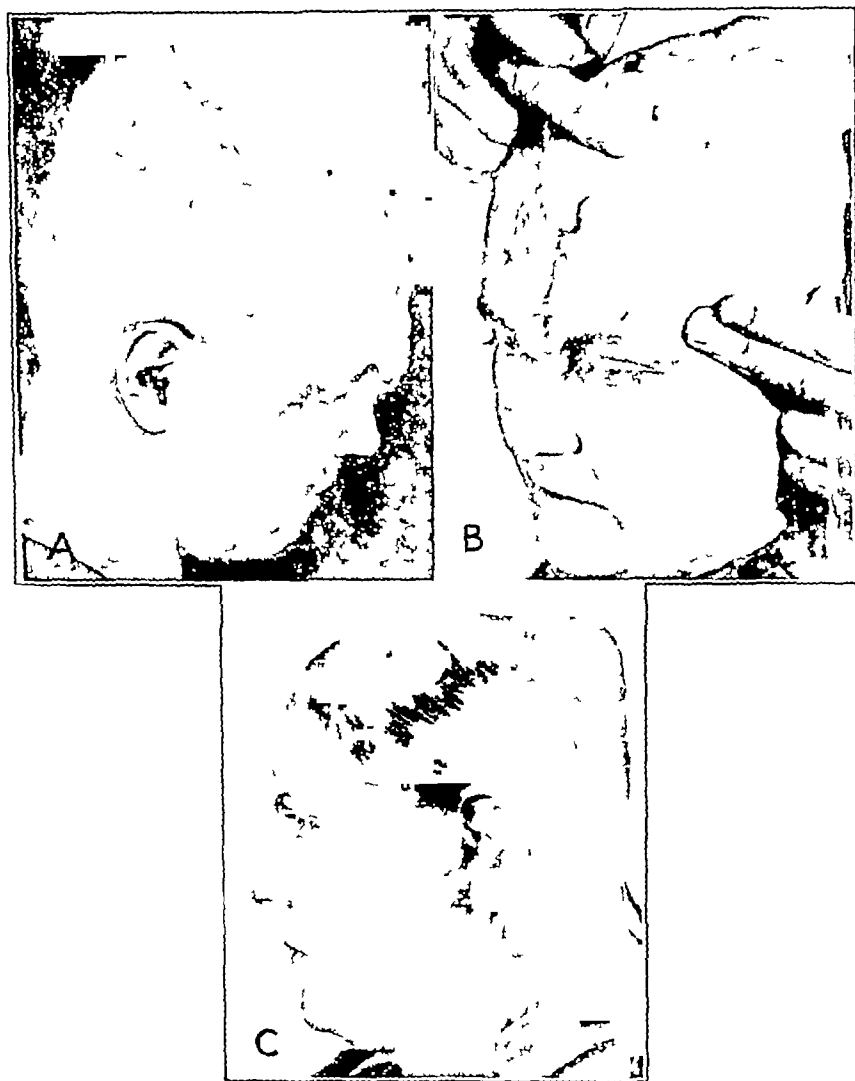


Fig 3 (case 3) —*A*, patient with extensive arteriovenous aneurysm of the scalp. Note the pronounced swelling in the parieto-occipital region. This is a congenital angiomatous mass from which the large dilated veins emerge to cover the head. The arterial supply of this aneurysm came from two arteries that passed through the skull, one from each middle meningeal artery. *B*, the effect of stripping and compression with the finger of the huge vein passing over the forehead. Since the arterial blood is shut off, the vein remains collapsed. *C*, the same patient five years after ligation of both external carotid arteries. The large veins thrombosed and disappeared after this procedure, but the primary angiomatous mass remains.

the nose and overhung the medial part of both eyes. This mass was slightly bluish. Another mass passed laterally in front of each ear, slightly covering the face. The central mass pulsed strongly, slight pulsation was present in the large vessels radiating from it, and a slight thrill could be detected on light palpation. The central mass was not tender. Compression of the superficial arteries did not influence the size of the swelling. On auscultation a slight murmur was heard, this became intensified with greater pressure of the instrument.

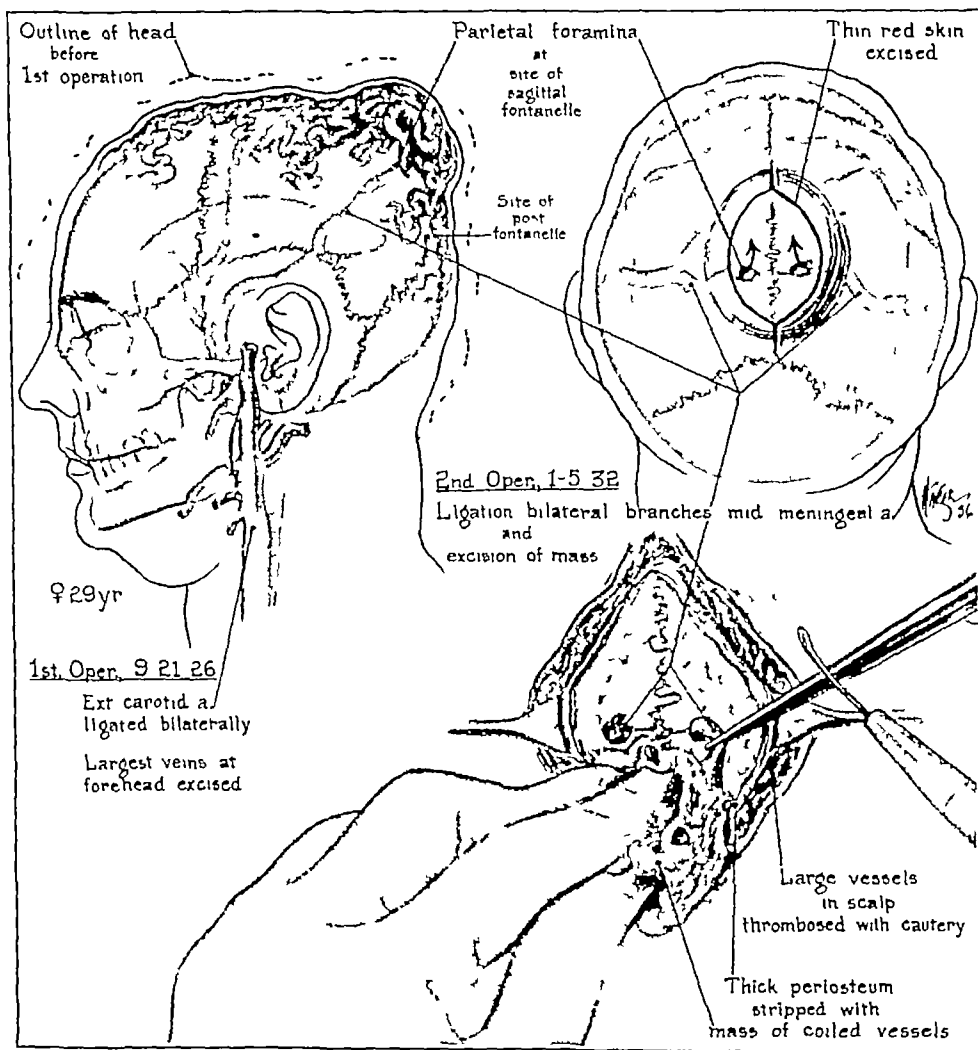


Fig 4 (case 3) —Operative sketch showing the two large vessels going through the skull (one from each side) to enter the arteriovenous aneurysm in the scalp

When the finger milked the blood backward in a big vessel from the nasion to the hair line (fig 3 B), the vessel was collapsed and a deep furrow resulted, indicating that the blood came from the central mass posteriorly. Both middle meningeal arteries were greatly enlarged in the roentgenogram and passed directly backward and upward toward the region of the extracranial angiomatic mass.

Diagnosis—The diagnosis was congenital arteriovenous aneurysm of the scalp, with a congenital coil of vessels in the midparietal region

Operation—On Sept 21, 1926, the external carotid artery on both sides plus both occipital, internal maxillary and superficial temporal arteries were ligated, the external jugular veins were oversize, and they were not ligated. Temporary compression of the common carotid artery did not appear to influence the size of the mass. The large vein over the forehead was ligated at the hair line. There was essentially no change in the size of the occipital mass, it may even have been a little more tense, and to the patient it seemed definitely tighter (from thrombus formation). The vein over the forehead remained collapsed. Six days later the pulsation in the mass had stopped (from thrombus formation) and the vessels in the mass and those radiating therefrom were firm and pulseless, with the excep-



Fig 5 (case 3)—Patient after removal of the angiomatous mass. There has been no recurrence since this operation thirteen years ago.

tion of one in the right temporal region. The veins of the forehead had collapsed. The headaches and the noise in the ears were no longer present.

Second Operation—On Jan 5, 1932 (five and one-fourth years after first operation), the patient returned because swelling in the back of her head persisted and pulsated (fig 3 C). Except for a fair-sized pulsating vessel in the occiput, there was no trace of the huge veins over the head and face that formerly were so prominent, the central mass was also much smaller. It did pulsate, though much less than before. She wanted to get rid of it.

An elliptic incision was made around a central area of thin red skin at the top of the mass and the mass was dissected from its bed. The periosteum was thickened and was not stripped from the bone. In the layer of thickened periosteum two fair-sized arteries emerging from the parietal foramina were thrombosed with the electrocautery (fig 4). Since there was no other source for these vessels—

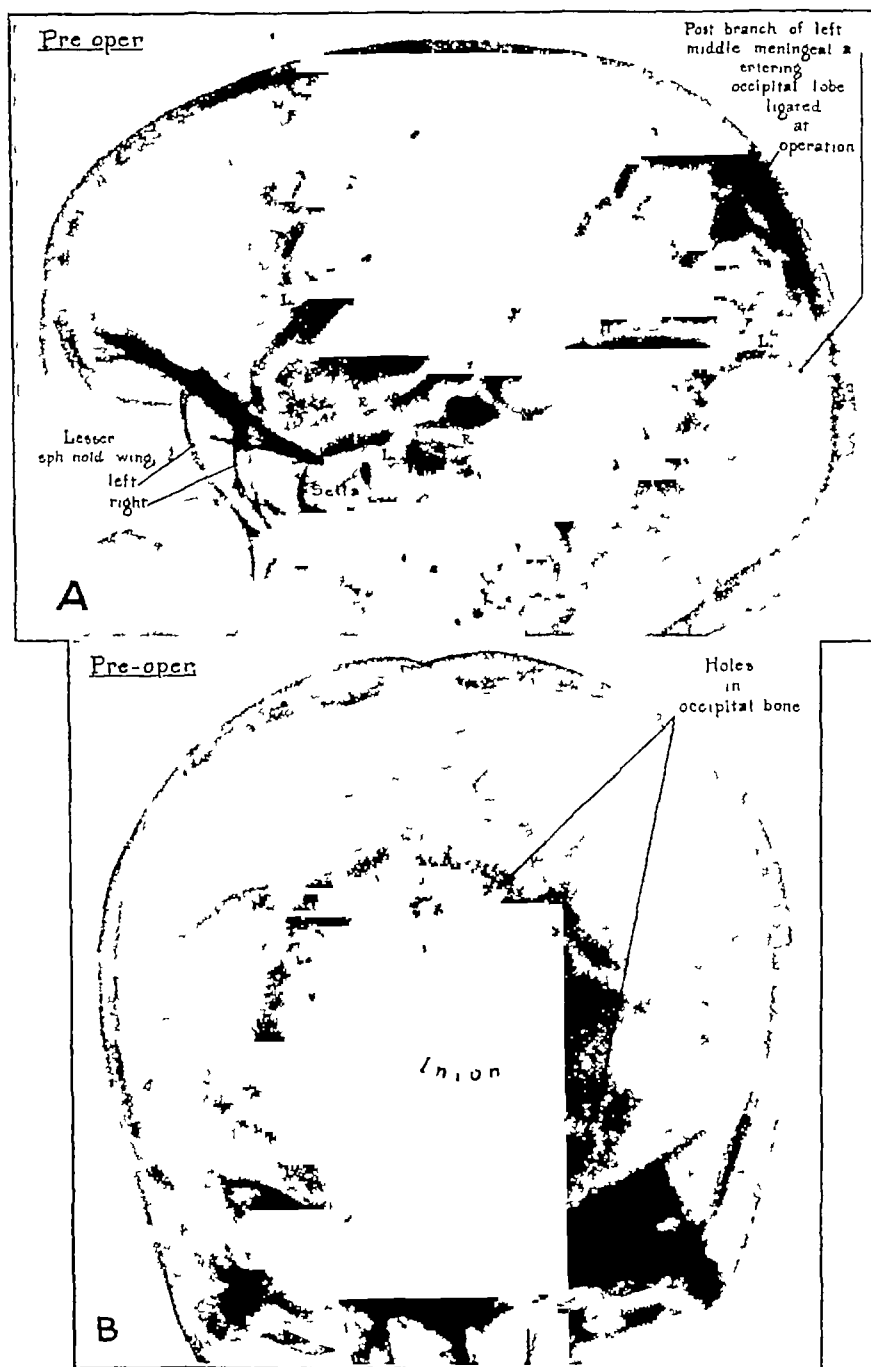


Fig 6 (case 4) —A, roentgenogram showing greatly enlarged grooves of the posterior branch of the middle meningeal arteries on both sides of the skull. These extended to the parieto-occipital region of each side, where numerous branches perforated the skull to form the venous components of the aneurysms in the scalp. (The roentgenogram has been retouched) B, anteroposterior view (case 4) showing numerous erosions in the parieto-occipital region due to perforations of the branches of the middle meningeal artery passing through the skull (Roentgenogram has been retouched)

all the lateral channels were severed—they had to come from the bone. It has been noted (in roentgenograms) that the middle meningeal arteries were greatly enlarged and were directed backward toward this mass. It is practically certain, therefore, that the arterial supply of the tumor was ultimately from this source. Since the skin was redundant, primary closure was attained in spite of the excised central area, the wound healed without sloughing (fig 5)

Subsequent Report—On June 1, 1945, thirteen years after extirpation of the mass, the patient was perfectly well, there has been no return of the aneurysm

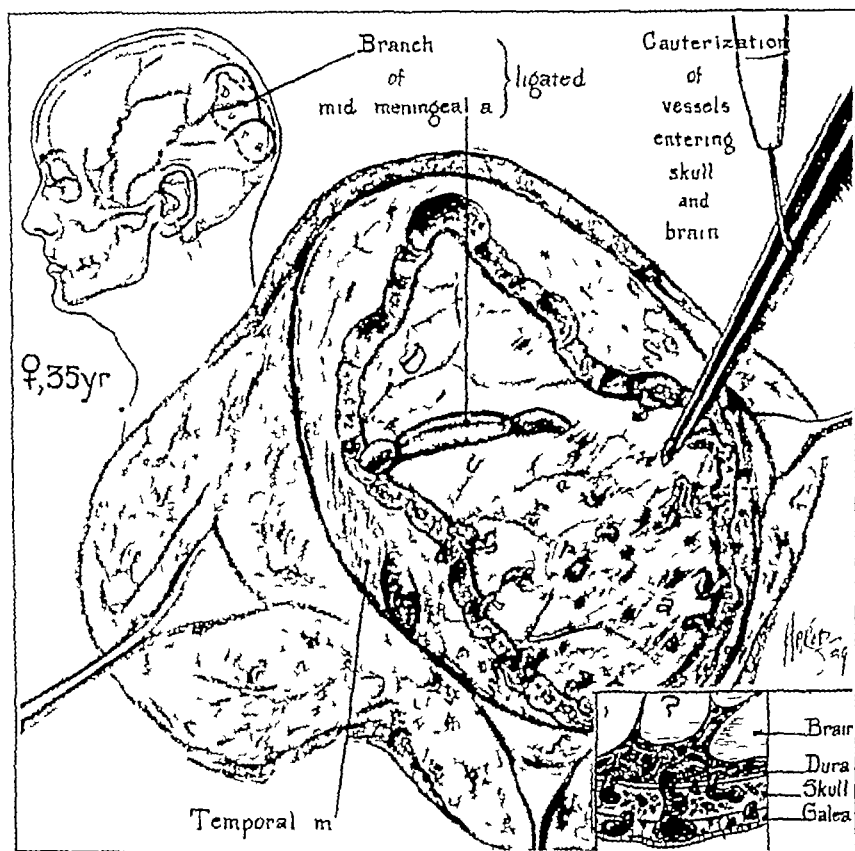


Fig 7 (case 4)—Operative sketch showing area of bone rongeured away piecemeal. Because of the extensive vascularity in this region, a bone flap could not be turned down safely. An extremely large middle meningeal artery was ligated, and numerous coils of this vessel in the dura were thrombosed by the cautery. Because of the right homonymous hemianopsia, it is almost certain that these arterial branches also passed into the occipital lobe.

CASE 4—Aneurysms of the dura, with extension extracranially

The patient was a normal-looking woman, aged 38. She complained of headache and noise in the head. She had been conscious of the noise for many years, but the headaches had begun only a month ago. Both the noise and the headaches were in the left occipital region and coincided with a roughly circular pulsating

mass 5 cm in diameter. There was a similar mass on the right, about half as large as the one on the left. A thrill could be felt and a bruit heard over both masses. The bruit was most intense in the occipital region but could be heard over the entire head and in the neck. The veins over the frontal and the temporal regions were conspicuous.

The patient had a right homonymous hemianopsia.

Roentgenograms showed greatly enlarged middle meningeal grooves extending straight back to the occipital region (fig 6A). In the parieto-occipital regions of both sides, the bone was extremely porous from numerous small erosions (fig 6B).

Operations—On Feb 13, 1939, an arteriovenous aneurysm in the left occipital region was removed, a flap being used. Arterial bleeding coming out of the bone was controlled by wax. The same operation on the right side was performed Feb 16, 1939. The bone was not removed on either side. On April 25 the bone was rongeuired away piecemeal under the previous flap (left side). The dura

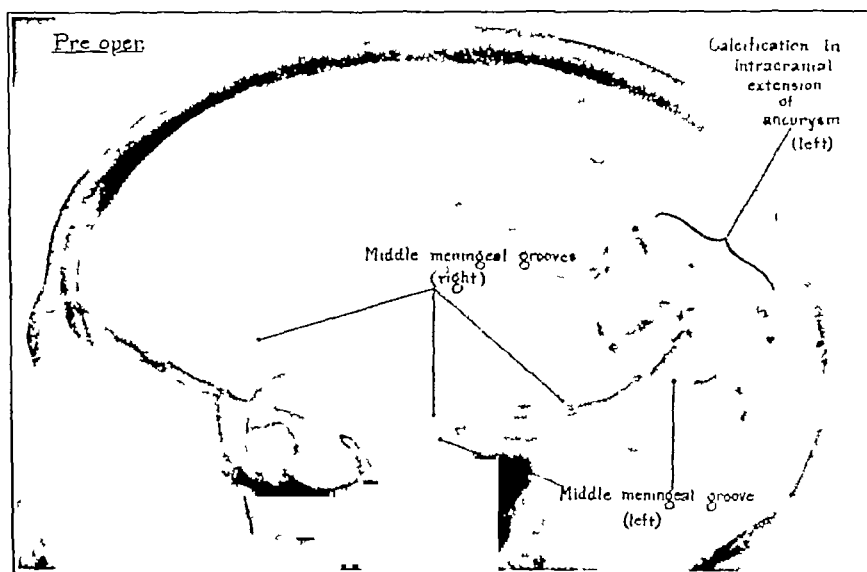


Fig 8 (case 5)—Roentgenogram of patient, aged 59 years, showing the greatly enlarged middle meningeal arteries directed backward to the parieto-occipital region, forming in the dura an extensive plexus, the branches of which perforated the skull to form the extracranial arteriovenous aneurysm. The numerous calcifications in the brain doubtless represented the intracerebral extension of the aneurysm and caused the right homonymous hemianopsia.

was extremely bloody, and coils of vessels filled the dura and projected outward toward the bone. They were coagulated with the electric cautery. The large middle meningeal artery was ligated (fig 7). The dura was not opened.

Subsequent Note—On May 1, 1945 (six years after the operation), the patient had had no headaches since operation. The aneurysms had disappeared.

CASE 5—A man aged 59, was rather ill-looking, walked poorly and with staggering gait and was deaf to conversational tones. He complained of general weakness.

Since early childhood he had had intermittent headaches. They were now bifrontal and occurred several times weekly, they were not associated with nausea

or vomiting For many years a subjective head noise that he could not localize had disturbed him His hearing had been defective for over twenty-five years, and he had been totally deaf for ten years He had a right homonymous hemianopsia but did not know when it developed Bilateral exophthalmos of moderate degree had also been present for years

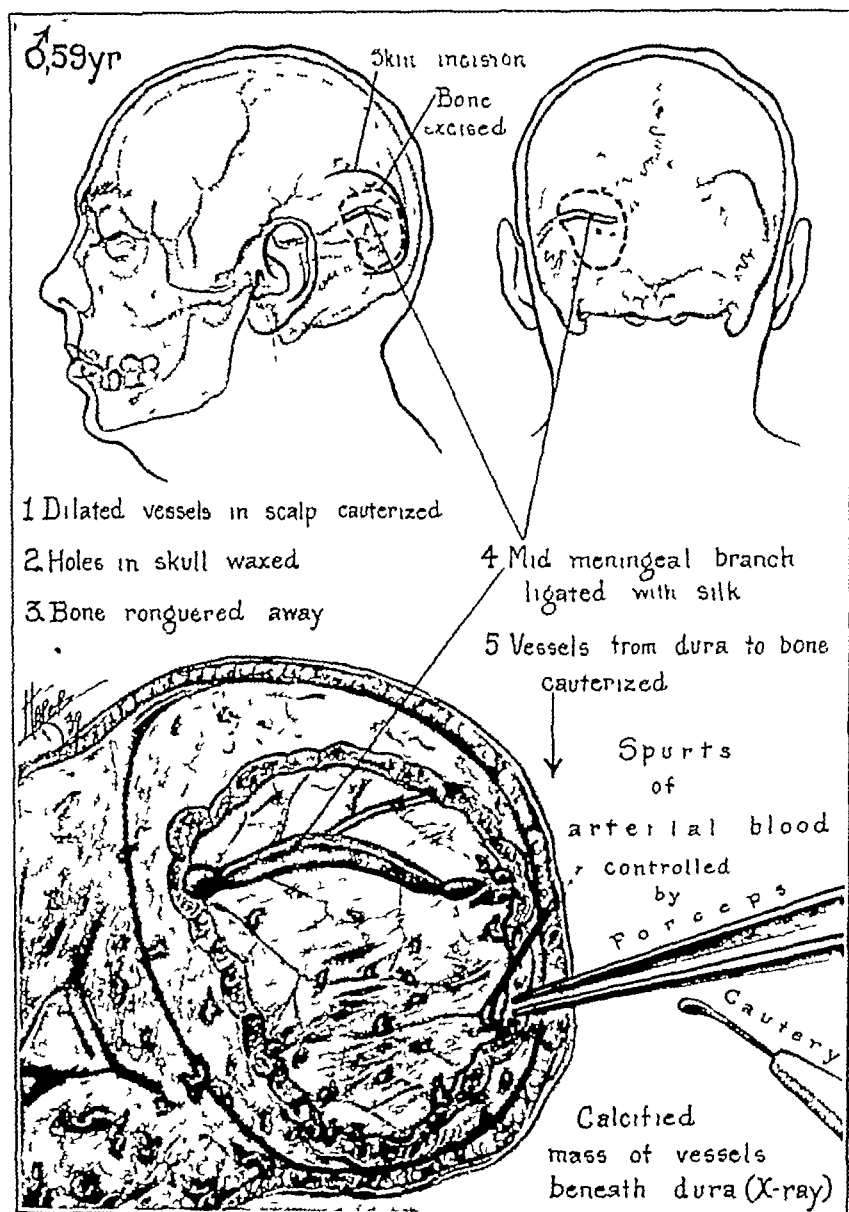


Fig 9 (case 5) —Sketch showing operative defect in the bone over the parieto-occipital region, where the greatly dilated middle meningeal artery with its plexus of vessels is exposed Numerous branches of this plexus perforated the bone and formed the extracranial aneurysm as in the preceding case This aneurysm also doubtless penetrated the brain on one side and produced a right homonymous hemianopsia, and the numerous calcifications in this region are almost positive evidence of deposits in the vessels in the brain

A year before he had begun to have general malaise and weakness and had difficulty in walking, especially in the dark (due to vestibular divisions of the auditory nerves) His wife said that he was becoming mentally sluggish, was disoriented at times and on numerous occasions had threatened suicide. There had been no convulsions

Examination—Examination revealed (1) in the left occipital region an expansile, pulsating mass, 5 cm in diameter (a systolic thrill could be heard over it), (2) in the right occipital region another mass of same kind but smaller, 3 cm. in diameter, (3) in the right vertex another similar mass (2.5 cm in diameter), (4) over both temporal regions many tortuous pulsating vessels, (5) right homonymous hemianopsia, (6) bilateral exophthalmos, (7) bilaterally equal loss of hearing below conversational level, (8) bilateral vertical nystagmus, (9) swaying broad-based walk, with a positive Romberg sign in all directions, (10) roentgenologic evidence of enormous bilateral middle meningeal channels, directed backward to the occipital region and numerous little erosions in parietal bones, and of several small calcified areas in the left parietal and occipital lobes (fig 8), and (11) stopping of the pulsation on the corresponding side by pressure on the carotid artery

Operation—On April 11, 1939, an occipital extracranial aneurysm on the left side was excised, a flap being used From the bone, arterial blood spurted in dozens of places, it was controlled by waxing

On April 19, under the cutaneous flap, the bone was rongeuured away piecemeal Dozens of little vessels were pulled out of the bone, many were thrombosed, but some still bled, they were attached to the dura and were continuous with the branches of the middle meningeal artery This vessel was as large as a slate pencil and was ligated (fig 9) The many bleeding points in the dura were coagulated with the cautery The dura was not opened

The patient was much improved on Dec 12, 1939 His headaches were now only on the right side, he was much better mentally The neurologic conditions had, of course, not changed The middle meningeal artery was tied on the right subtemporal approach

Comment—This case is very similar to the preceding one in many of the subjective and the objective findings On July 20, 1945, six and one-fourth years after operation, the patient was free of all headaches and leading a normal life

CASE 6—A pale, undernourished man, aged 46, had never been well, he had always been easily exhausted and had had numerous complaints Generalized headaches had begun fifteen years before consultation and were intermittent until one year before he was seen, when they became constant Since losing a good job five years before, he had been nervous, depressed and subdued and had had a definite personality change For six weeks there had been an occasional noise in the right ear His complaints were those characteristic of psychoneurosis However, for the past two months he had had intermittent attacks of numbness in the left arm and leg but no actual convulsions The examination disclosed numerous large dilated and tortuous vessels in the scalp, over which a thrill could be felt and a murmur heard These were more pronounced in the occipital region, the vertex and both temporal regions There was no concentrated mass of vessels as in other cases There was a small hemangioma on the right upper eyelid and a birthmark in the midline of the upper lip, neither associated with the vascular masses

The roentgenogram showed three small calcified areas in the leg area of the right side—doubtless the cause of his sensory seizures (fig 10)

Operation—On July 31, 1942 a bone flap was contemplated to remove the calcified areas in the right hemisphere, but the bone was covered with tiny holes from which arterial blood spurted and was controlled by wax, the sharp bleeding was from the vessels supplying the extracranial arteriovenous aneurysms. Continuation of the bone flap would have courted severe hemorrhage. Instead, the bone was rongeured away by bits, and each bite of the bone was attended by brisk bleeding. The exposed dura was covered with large vessels, branches of the middle meningeal artery, these were coagulated with the electrocautery. The

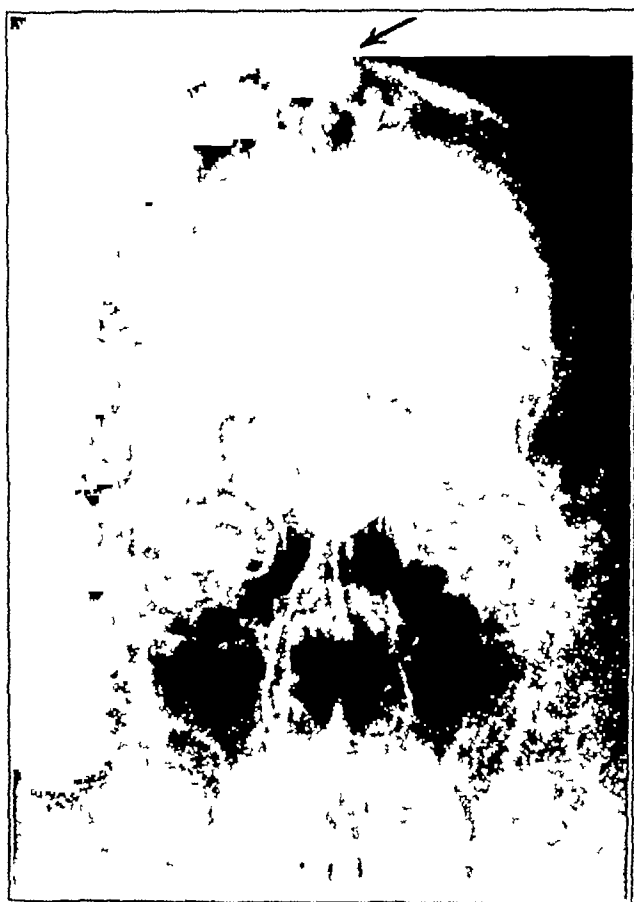


Fig 10 (case 6)—Anteroposterior roentgenogram showing calcifications along the falx. These calcifications were not subjacent to the aneurysm but were independent of it. They were causing the epilepsy and were not related to the arteriovenous aneurysm.

dura was turned back and three small bony spicules removed from the brain in the neighborhood of the longitudinal sinus, one was flat and on the surface of the pia, and each of the other two was perhaps 2 cm in length and projected into the brain tissue. All were easily removed. In this limited exposure the suspected intracranial aneurysm was not visible.

CASE 7—A normal-looking man, aged 42, had had headaches for fifteen years, at first they had occurred every two or three months, lasting from a few hours to a day, and had ended with vomiting. For the past two years the headaches had been almost constant. They were mainly on the left side and affected the eyes, the face, the gums and the back of the head and neck. A visual aura had preceded the attacks, blindness lasted from thirty to forty-five minutes when headaches followed, but there were many attacks of blindness without headaches, the blindness then lasted longer, thirty to forty-five minutes. At times there was numbness of the left hand, and at times there was difficulty in expressing himself and naming objects.

Examination—1 There were enlarged tortuous vessels over the left parietal and occipital regions, but there was no visible or palpable localized mass of vessels. 2 A bruit was heard over the entire skull, but it was more pronounced in the left parietal and mastoid regions. 3 There was a homonymous hemianopsia to the right. 4 A roentgenogram of the skull showed a greatly enlarged left middle meningeal artery directed backward to the left occipital region (fig 11). This

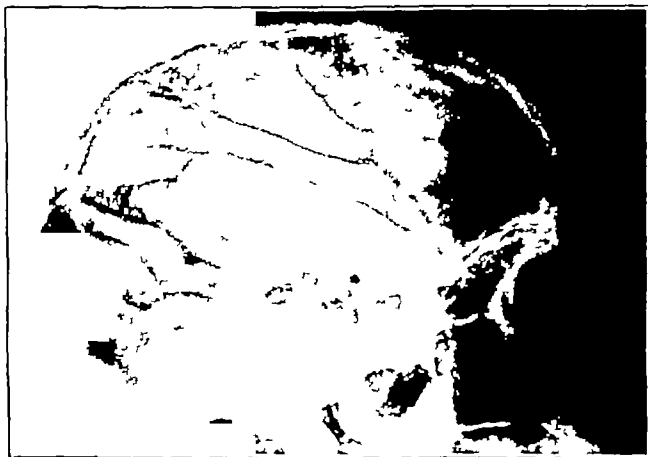


Fig 11 (case 7) —Roentgenogram showing the large middle meningeal grooves extending to the parieto-occipital region where the arteriovenous aneurysm presented extracranially (Roentgenogram not retouched)

involved only the posterior branch of the middle meningeal artery, the anterior branches being normal. 5 There was a small diffuse area of calcification in the depths of the parietal lobe.

Operation—On Dec 30, 1944 both middle meningeal vessels in the parietal region were ligated.

The patient returned because of continued headaches and a second operation was performed, Nov 1, 1945. The parieto-occipital region on the left side was rongeuured away piecemeal, as in the other cases, until a defect as large as the palm of one's hand was made. There was no undue bleeding from the bone except in the mastoid region, which was extremely bloody, here the bone was stripped and waxed, as in the other cases. The dura was turned back over the entire area. There was intracranial pressure of high grade, the brain bulging tremendously. A large arteriovenous aneurysm covered much of the temporal and parietal lobes, it extended from the inferior surface of the temporal lobe, covered

in lesser degree the parietal lobe and emerged at the mastoid region, where the dural and extracranial connections were made

Subsequent Course—The patient has just left the hospital. His headaches had ceased, relief of the intracranial pressure was due to the large decompression

CASE 8—A white woman, aged 31, was referred to me by Dr Charles Wainwright, of Baltimore. Her first complaint was dimness of vision, beginning six years before and occurring only at times, but it had been so disturbing that an ophthalmologist was consulted. At this time she was said to have had bilateral papilledema and was referred to a neurosurgeon, who on three occasions attempted injection of air via the ventricles and the spinal canal, but without successful filling of the ventricular system. Following these procedures, headaches first appeared and were attributed by her to the punctures. The headaches had been confined to the left side. There was a sensation of fullness and a dull aching, and both were practically continuous, though with variations in degree. Injections of histamine did not



Fig 12 (case 8)—Roentgenogram (not retouched) showing the enlarged posterior branches of the middle meningeal arteries on both sides. On the left side, the branches ultimately form a network.

influence the headaches. She had had two hospital admissions to Dr Wainwright's service, June 30, 1943 and July 18, 1945. Since her first admission she had had four convulsions, three of these were in rapid succession.

Examination—The patient was well developed and well nourished. The only significant finding was a homonymous hemianopsia for form and color on the right side. On three occasions the Wassermann test of the blood elicited a positive reaction, and, on the assumption that there was a cerebral syphilitic process, she had received antisyphilitic treatment for eighteen months.

The roentgenogram showed bilaterally symmetric, large posterior branches of the middle meningeal arteries, these were directed backward toward the occipital region and were considered pathognomonic of an arteriovenous aneurysm of the dura (fig 12). Following this interpretation, auscultation disclosed a murmur over most of the head but of greatest intensity over the parieto-occipital region and

more on the left side. No mass could be felt, but after the head was shaved, preparatory to operation, a soft boggy mass was palpable mesial to the left mastoid, this pulsed strongly, and there was a thrill. There were no intracranial calcifications and no evidence of porosity of the bone in the roentgenogram.

The patient had been extremely emotional. She "cried every day" and after a "good cry the headache was always better." But a psychoneurotic headache would not have been localized to one side of the head.

Operation—On July 26, 1945, a semicircular flap of scalp was turned back in the parieto-occipital region. Bleeding from the bone was furious, dozens of spurting vessels were waxed after the bone had been scraped. As in the preceding cases, a bone flap could not be considered, because of the excessive vascularity. This

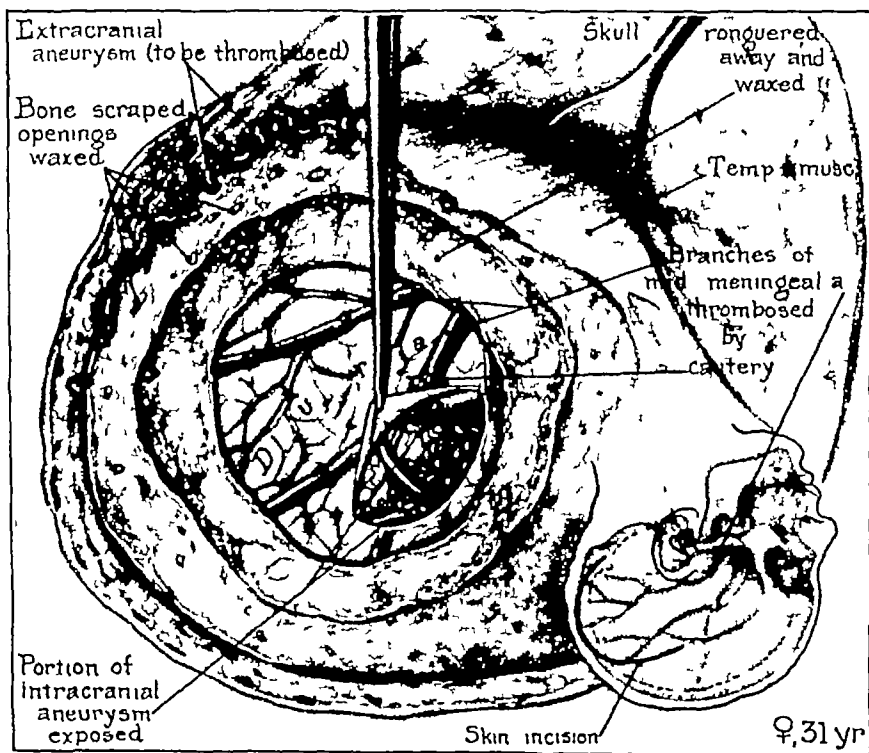


Fig 13 (case 8)—Operative sketch showing the defect in the bone, the large middle meningeal artery and branches and a small exposure of the intracranial aneurysm.

area of skull was rongeured away piecemeal until dura, about 5 by 5 cm, was uncovered. The middle meningeal trunks were large, and these and numerous spurting branches in this membrane were thrombosed with the electrocautery. The bone was quickly waxed after each bite was removed. A small opening was made in the dura, and a small dural flap was begun but not completed because of bleeding. Large vessels of an arteriovenous aneurysm covered the brain (fig 13). The exposure was too small to determine the arterial connections of the aneurysm.

CASE 9—A youth, aged 19, was referred to me by Dr. M. Douglas of Harrisburg, Pa., Aug. 29, 1933, because of a midline pulsating swelling on the forehead.

(fig 14) (This case was reported by Brock and Dyke [1932], but before the operations)

Present Illness—The father had noticed a bean-sized swelling at the root of the nose when the boy was 2 or 3 years old. The tumor had grown slowly and steadily, and when the boy was 6 it was the size of a thumb and was then known to pulsate. Aside from a rushing noise in the head, there had been no symptoms. There was an indefinite history of a bump on the head when the boy was 2, but the parents could not suggest a definite relationship to the onset of the tumor. The patient had never had convulsions.

Examination—The tumor was in the exact midline of the forehead and extended from the hair line to the bridge of the nose, it measured 5 cm in length and 3.5 cm in width and was elevated about 2.5 cm. It had a bluish tinge and pulsated strongly, and a pronounced thrill was imparted to the palpating finger. At the bridge of the nose the swelling was not so high but extended to the inner canthus.



Fig 14 (case 9)—Photographs of patient before and after removal of the arteriovenous aneurysm in the forehead. The scar of the intracranial exposure of the aneurysm is also shown in the postoperative photograph.

of the eye and gave the impression of a rather wide nose and of the eyes being farther apart than normal. There were small telangiectases over the eyelids and some on the face.

Pressure on either internal carotid artery did not eliminate the pulsation. On palpation, one had the impression of entwining vessels.

On auscultation, a murmur was heard over the mass and over the whole head and down both sides of the neck. The only positive neurologic findings were (1) general constriction of the fields of both eyes, (2) nasal hemianopsia on the left, (3) left homonymous hemianopsia for blue only and (4) reduction of visual acuity on the left to 20/50, the visual acuity on the right was 20/20.

The roentgenogram showed multiple thin, straight and curved calcified linear shadows, suggesting plaques, in walls of blood vessels (fig 15). The frontal bone was extremely thin.

Impression—The intracranial calcifications and the partial homonymous hemianopsia made an intracranial lesion certain. And since the extracranial lesion was an arteriovenous aneurysm, it was practically certain that the intracranial lesion would be of the same character.

First Operation (Aug 30, 1933)—A left anterior craniotomy, exposing the frontal lobe and extending close to the longitudinal sinus, was performed. The bone flap was extremely bloody, this had been anticipated because of the large middle meningeal artery shown in the roentgenogram. When the dura was turned back, an arteriovenous aneurysm so completely covered the entire exposure that

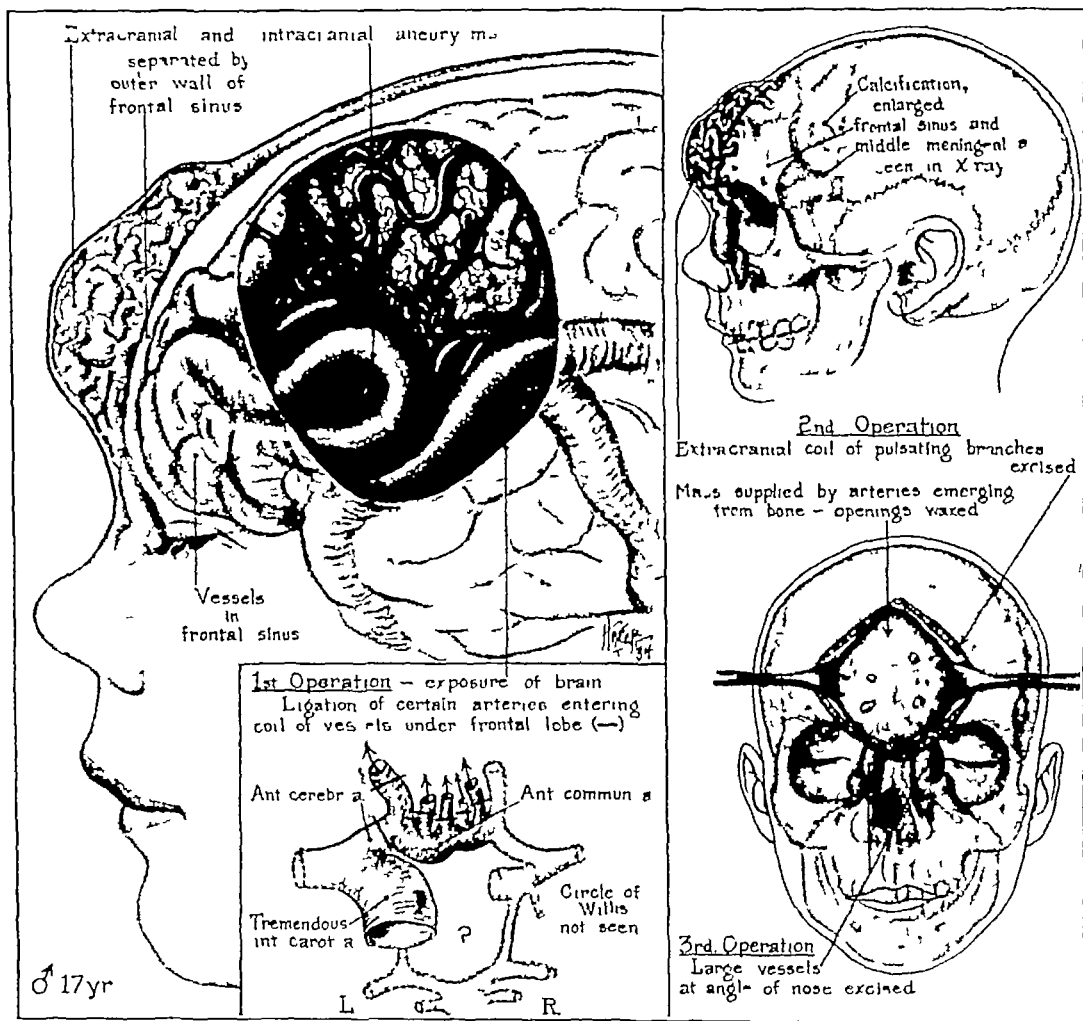


Fig 15 (case 9) —Operative sketch showing the enormous intracranial venous aneurysm and the smaller extracranial aneurysm on the forehead. No connection between the two could be demonstrated. The huge vessels in the intracranial aneurysm carrying arterial blood are the largest I have ever seen in the brain. The lower left inset shows the group of vessels that were ligated in the hope of eliminating the arterial circulation to the aneurysm. The lower right inset shows the perforations in the bone that fed the extracranial aneurysm. These vessels are derived from the middle meningeal artery, a sketch of which is shown in the upper inset.

little brain tissue was visible. One enormous vessel, pink from arterial blood, skirted the posterior part of the exposure and curved forward toward the tip of the frontal lobe. A second vessel, of similar size, curved backward toward the temporal lobe, where it was lost to view. These two vessels were much the largest vessels I have ever seen in the brain. They were as large as one's little finger and pulsated violently. The walls were fairly thick but not so much as those of an artery (fig 15). Numerous large coiled vessels covered the frontal lobe. Three large vessels crossed to the longitudinal sinus and were thrombosed with the electrocautery and divided. A mass of vessels extended to the tip of the frontal lobe but could not be traced through the bone, i. e., to connect with the aneurysm on the forehead.

The left frontal lobe was then elevated and the internal carotid artery exposed and isolated. Perhaps half a dozen fair-sized crossing vessels of the aneurysm were thrombosed and divided before the carotid artery was reached, all were in the neighborhood of the carotid artery and completely hid it from view. The internal carotid artery was the largest I have seen before or since and was only slightly smaller than the enormous vessels on the surface of the aneurysm. The anterior cerebral artery, at least twice as large as normal, was doubly clipped and divided and the ends coagulated with the cautery, four large branches of this vessel extending to the right side were also thrombosed and divided (fig 15). It was our belief that the arterial supply of the aneurysm was from the anterior cerebral artery, and it was our plan to remove the arterial component as completely as possible. This interpretation of the arterial supply may or may not have been correct. However, after these ligations the pulsation in the large trunks in the aneurysm ceased. These huge vessels on the surface were then coagulated with the cautery and were largely obliterated. This could not have been attempted during their pulsation, they would surely have ruptured. It was also noted after the operation that the pulsation in the extracranial aneurysm was absent. On the following day, however, a faint pulsation had returned, and it steadily increased. Whether this temporary cessation of pulsation resulted from the absence of pulsation in the intracranial aneurysm or from the cutting of the middle meningeal artery when the bone flap was made cannot be stated. Perhaps both may have been responsible. Certainly the middle meningeal artery supplied the aneurysm directly through the skull (fig 15). No actual continuity could be established between the intracranial and the extracranial aneurysms, and it is difficult to believe that such a communication was possible with the skull intact. However, this is only an impression, which may or may not be correct.

Postoperative Course—The patient's recovery was uneventful (fig 14). He returned ten months later for removal of the extracranial aneurysm on the forehead. This was somewhat though not much smaller than before operation.

Second Operation (June 20, 1934)—The mass was excised through a midline incision. Four fair-sized vessels, with thin walls but with arterial pulsation, came through the bone into the aneurysm, these were thrombosed and the bone scraped and waxed. The aneurysm was made up of coils of small vessels (fig 15).

Third Operation (June 27, 1934)—Since a fulness remained at each side of the nose and extended toward the inner canthus of the eyes (fig 15), an additional extirpation of these portions was thought to be indicated to improve the appearance. On June 27 this was done on the left side, but the procedure was so bloody that the operation on the other side was not done. I am still perplexed to explain the existence of such a vascular mass after the aneurysm on the forehead had been excised.

Subsequent Course—The patient was discharged from the hospital July 18. The extracranial aneurysm did not return.

On Jan 2, 1937, two and one-half years later, his death was reported, "cause unknown." Six months before death, convulsions had developed.

In retrospect and with a more extended experience with these lesions, I doubt that the operative attack on an intracranial aneurysm of this type is indicated. It is extremely unlikely that the entire arterial supply of such an aneurysm could ever be completely eliminated, because of the extensive collateral circulation. In none of the other cases has the intracranial aneurysm been molested, and in only 2 has it been exposed.

COMMENT

This group of aneurysms, together with those reported on in the literature, indicates clearly that there are two sources of origin. Most of them arise congenitally, but many develop in the later years of life from trauma and without a preexisting vascular lesion. In only 1 of our 9 cases is the aneurysm known to be traumatic in origin (case 1). In case 2 it may or may not be of traumatic origin but it is more probably from a congenital nevus, though it was not recognized. In the remaining 7 cases they are known to be congenital in origin. In the traumatic cases, it can only be said that as a result of the injury an arteriovenous connection has been established between small arteries and veins. Although there are certain sites of predilection for the congenital aneurysms, particularly the scalp and the back of the ear, they may occur almost anywhere.

In this series of 7 cases of arteriovenous aneurysms of the scalp, it is clearly shown in all that the arterial component is derived from the middle meningeal artery and therefore that the arterial blood comes through the skull from the cranial chamber. This statement does not mean that all such aneurysms have intracranial connections, but it does indicate the frequency of this source of arterial supply and, I think, it also indicates that this is the usual if not the sole origin. This intracranial arterial supply explains why ligations of any and all the arteries in the scalp make no impression on the pulsation or the size of the extracranial aneurysm and also why ligation of the external carotid artery does reduce the pulsation and size to some extent. The external carotid artery cuts off blood supply from the middle meningeal artery. When both external carotid arteries are ligated—and this can be done with impunity—the pulsation of the aneurysm is completely stopped, but the effect is only transient because of the extensive collateral circulation that obtains.

There are two types of arteriovenous aneurysms of the scalp (fig 16) (1) that in which one, two or perhaps more preformed genuine arteries come through the skull and enter a primary congenital

angiomatous mass on the exterior (in case 3 the arteries passed through the parietal foramina, one on each side) and (2) that in which numerous thin-walled vessels penetrate the skull and form an arteriovenous bed without a primary angiomatous mass in the scalp (cases 4, 5, 6, 7, 8 and 9 are of this type). In the latter group the arteriovenous bed in the scalp is smaller, at least in none of these cases has it approached the size of the beds in the first group, and in 1 case it was demonstrable only after the head was shaved. In 5 of the 6 cases in this group an arteriovenous component of the aneurysm was also in the cerebral hemisphere. Whether or not this ever obtains in the first group cannot be stated, it has never been demonstrated, and because of the great size of the extracranial aneurysms my guess would be that there are no intracranial components. Both types are prone

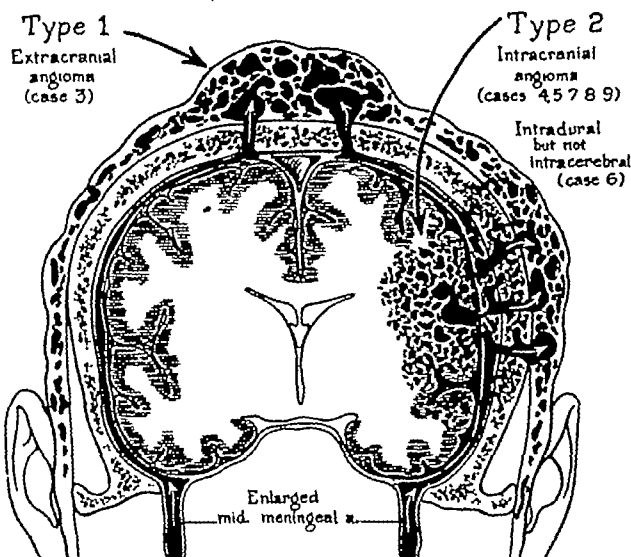


Fig 16—Diagram showing the two types of extracranial aneurysms, both arising from the middle meningeal artery. In type 1 the extracranial aneurysm is supplied by preformed arteries coming through the skull and entering an angiomatous mass, and in type 2 there are numerous branches of the middle meningeal artery penetrating the skull over a wide area and forming the arteriovenous aneurysm extracranially. In type 2 the aneurysm usually but not always extends into the cerebral hemisphere.

to have a bilateral arterial supply from the middle meningeal arteries, but in some it is unilateral and in most it is greater on one side than on the other. In the second group, the vessels penetrating the bone are so thin-walled that they are not recognizable. When the galea is turned back, they rupture at the bone and are controlled by waxing. The bleeding is so furious that wax must be applied quickly and in large amount. In the first group the vessels were preformed and the firm walls permitted their isolation and control by ligatures. The diffuse vascularity of the bone in the second group is similar to that

arising from the highly vascularized dura that develops over dural meningiomas

The perforations in the skull from these vessels frequently show in the roentgenogram, and in 1 case the affected region of the skull appeared moth eaten from the vascular perforations. Moreover, in these 6 cases the great arterial varices in the dura were seen after removal of the bone, in every case (except case 7) the bleeding was too severe to warrant turning down a bone flap, instead, the bone was removed piecemeal with rongeurs. In 6 of the 7 cases the grooves in the oversized middle meningeal arteries were strikingly shown in the roentgenogram and were directed backward to the vascular bed in the skull. In all but 2 of our cases the aneurysm was in the parieto-occipital region (in case 7 it was in the temporal lobe), and it is the enlargement of the posterior branch (normally inconspicuous) that is all-important in the roentgenologic diagnosis of this lesion. In 5 cases, both the right and the left meningeal arteries were about equally enlarged, although the size of the extracranial aneurysm varied on the two sides, and always the hemianopsia indicative of the intracerebral aneurysm was unilateral.

In 5 of these cases there is proof that the brain was also involved in the aneurysm, for in each there was a right homonymous hemianopsia, which could be explained only by the invasion of the visual area in the occipital or temporal lobes by the aneurysm directly overlying it. In 3 cases (cases 5, 7 and 9) numerous calcifications in the brain indicated the extension of the aneurysm into the subjacent brain. These have been linear in 2 cases and diffuse in the third, the linear shadows suggest calcification of walls of blood vessels. The fact that epileptic attacks have been reported in at least 6 cases in the literature, 1 of Clairmont's (1908), 1 of Elkin's (1923) and 4 of ours, is suggestive but not conclusive evidence of a cerebral extension of the lesion. In 1 of our patients (case 6) in which the cerebral hemisphere was exposed the seizures were not due to extension of the aneurysm into the brain but to three dense bony plaques of congenital origin. Moreover, these plaques were at a distance from the site of the aneurysm in the dura and not subjacent, as in case 5. Since congenital lesions are not infrequently multiple and of different types, an intracranial extension of an aneurysm cannot be accepted purely on the basis of convulsions, the aneurysm may or may not be responsible. The 5 cases with right homonymous hemianopsia, however, could leave no doubt concerning the intracerebral extension of the aneurysm and of the convulsions when they were present. The intracranial aneurysm was demonstrated in 3 cases at operation. In the case of 1 patient with an enormous intracranial aneurysm, there had never been convulsions,

he was 19 years old. However, convulsions finally developed before his death, two and one half years after operation.

The large middle meningeal arteries directed toward the location of the angioma have been commented on by Clairmont (1908),⁸ Elkin (1923)¹ and Rundle (1938),¹⁴ and all considered the possibility of this source of the arterial blood. Elkin and Cushing, who operated on the patient, concluded it to be "a mistaken idea," and in a recent communication to me Elkin still maintained this view. Elkin stated that Guérin (1870) suggested the possibility that the lesion might extend intracranially. In looking at Cushing's operative sketch in the paper by Elkin it should be perfectly clear that the arterial blood does come through the bone and therefore from the middle meningeal artery, because the central mass of the aneurysm is encircled by the incision and could therefore get no possible arterial blood from the scalp, since the vessels still bled briskly, the blood had to come through the skull. Moreover, Cushing did not separate the vascular mass from the skull but was content to make numerous ties of the protruding vessels. In such circumstances, a cure, if it resulted, could have come only from extension of thrombus formation resulting from the ligatures, a not impossible outcome. In a recent letter Elkin stated that the patient was cured. A photograph of the patient after operation, however, still shows a swelling at the original site, Elkin explained this as edema of the tissues.

It is difficult to believe that such large and misdirected middle meningeal vessels do not carry pathognomonic significance concerning the arterial supply of the aneurysm, and in our direct exposure of these vessels in the 7 cases this conclusion is inescapable. In 1 case (case 8) the diagnosis was made solely on this finding in the roentgenograms, and this led to the discovery of the murmur and the extracranial aneurysm.

It is worthy of comment that all these patients have been highly nervous, and after cure of the headaches and the head noises the nervous condition, while improved, has continued in most cases.

A review of the relative size of the extracranial component in the 7 cases of arteriovenous aneurysm of the scalp leads us to believe that the size of the extracranial aneurysm is probably inversely proportional to the size of the intracranial component of the aneurysm, i. e., when the extracranial aneurysm is small, the intracranial portion is extremely large and when the extracranial part is large the intracranial part, if any, is small. This has at least been true in the cases reported here.

THE TREATMENT

In recent years, with improved hemostasis, most of the patients have been treated by extirpation, with little mortality. Even in the past

century there were many successful extirpations, usually, but not always, in two or three stages. During the past century, however, many aneurysms were injected with corroding solutions or treated by galvanic punctures, with a surprising number of cures. The end result was attained by thrombosis of the vessels, after which the mass gradually disappeared. However, in most instances there was only improvement and frequently only for a time, one or more repetitions of the treatments brought the final disappearance of the lesion. In many cases severe infection followed the injections, and this at times induced the cure by thrombosis, but a rather large number of deaths resulted from the infections. Kummell (1883)²⁸ reported six deaths in 15 collected cases in which injections had been used. The fact that severe "inflammation" helped the disappearance of the aneurysm was even recognized in the period before Lister's discovery of the cause of infection. Cures by injections are still occasionally reported. Fite (1933)²⁵ reported a cure by injections of boiling water. Patey (1942)¹⁶ tied both external carotid arteries and cured the aneurysm by injections. Klass (1942),²⁹ using sclerosing injections, brought about the complete disappearance of a large aneurysm involving the ear, had the mass been extirpated, two thirds of the ear would have been sacrificed. Davies-Colley (1940)¹⁵ reported a remarkable cure of a big aneurysm of the forehead and covering the bridge of the nose and an eyelid, the cosmetic result was doubtless better than by operation, since no scar remained, in another of Davies-Colley's cases, the patient died twenty-eight hours after an injection. One cannot deny the value of injections, and doubtless in experienced hands the risk is not great, moreover, there are times when the cosmetic results will be better. In safe hands, however, and certainly for aneurysms back of the hair line, surgical removal is better and safer.

During the nineteenth century, ligation of the common carotid artery, even on both sides, attained a great vogue. It is difficult to understand why the common carotid arteries should have been ligated instead of the external carotid arteries, from which the blood supply is derived and the ligation of which is harmless. The summarized results of Heine (1869)² and Korte (1880)⁵ show this procedure to have been almost routine. The size of the aneurysm was always reduced by the ligations, but within a short time the pulsation had returned and the lesion continued to grow. As a matter of fact, ligation of the common carotid artery can carry less effect on these aneurysms than ligation of the external carotid artery because the return flow

28 Kummell, H. Zur Behandlung des Angioma arteriole racemosum, *Arch. f. klin. Chir.* **28** 194, 1883.

29 Klass, A. A. Cirsoid Aneurysm Affecting Auditory Auricle, *Canad. M. A. J.* **46** 370, 1942.

of blood from the internal to the external carotid artery quickly overcomes the transient effect of closure of the common carotid artery. And it should again be noted that a number of hemiplegias and deaths followed ligations of the common carotid arteries. Ligation of any of the large arteries in the neck probably never cures an aneurysm and can improve it for only a short time. Thrombosis could conceivably result from such ligations and thus produce a cure, but so many failures are recorded that one is led to suspect that thrombosis occurs mainly through the venous components of the aneurysm. In our case, ligations of the external carotid arteries plus one large vein in the scalp produced widespread thrombosis that cured all the emissary vessels from the aneurysm and even reduced the angiomatous mass.

One can only marvel at the results attained by surgical treatment before Lister made open operation safe and at a time when hemostasis was far less secure. The cure of a large aneurysm of this type in 1829, by Benjamin Brodie, one of the great names in English surgery, provides most interesting reading of one of the earliest cases treated by surgery. This patient had been seen by Sir Ashley Cooper, probably the most famous surgeon in the world at that time. He had treated her with compression bandages, without result. Since the lesion was growing steadily and causing much discomfort he yielded gracefully to Brodie's suggestion of a surgical attack that Brodie had conceived. Brodie's ingenious procedure was to pass two large curved needles at right angles through the skin and under the tumor, grazing the bone, by traction on the needles the aneurysm was elevated, and a heavy suture was then drawn around the skin beneath the needles. By drawing the suture tight, the tumor was strangulated at the base. This procedure was repeated three days later and again on the fifth day. The mass sloughed away, healed by granulation and did not recur. The accompanying copy (fig 17) of a drawing from Sir Charles Bell's "Surgical Observations" (1816)³⁰ shows the use of a tenaculum to elevate a tumor and is similar in principle to Brodie's needles.

The case reported by Warren, of Boston (1867),¹⁷ almost forty years after Brodie's operation, is also noteworthy and the tumor was treated in much the same manner. It was a case of one of the extremely large aneurysms and much like our case 1.

Included in the reports of Heine and Korte (to 1880) are records of 10 cases of extirpation of the aneurysm, with cures, in 6 of these, both common carotid arteries were ligated after intervals of several days, and, curiously, none of the patients died, although there were two deaths following ligations of the common carotid artery. The first

30 Bell C. Surgical Observations. London: Longman [and others], 1816.

ligation of the external carotid artery (instead of the common carotid artery) for this purpose was probably performed by Maisonneuve (1851)

At the present time there should be little hazard in the extirpation of these aneurysms because of better hemostasis in the scalp, by the use of the electrocautery, bleeding vessels in the central mass can be coagulated. Despite the great size of the radiating, pulsating vessels they may be compressed by the fingers on each side of the incision and the ends sealed by turning the galea over them with clamps. The central mass, which is the only part of the aneurysm that needs extirpation, is then isolated and can be quickly excised from the skull, from which the vessels enter, or the mass can be scraped off the skull with a periosteal elevator and the mouths of the bleeding vessels closed with bone wax. After removal of the central mass, the large veins that

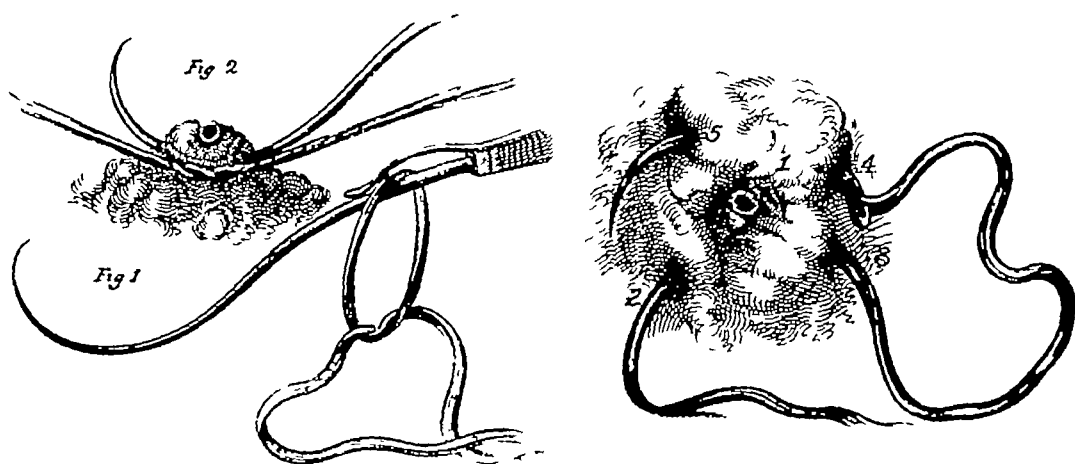


Fig 17—Drawings taken from Sir Charles Bell, 1816,³⁰ showing (a) method of elevating vascular mass with the tenaculum and the ligature placed around it and (b) method of deep sutures to constrict the vascular area that is bleeding. By these two methods, Benjamin Brodie made a remarkable cure of a large arteriovenous aneurysm of the forehead in 1829. Considering the fact that this was over one hundred years ago, it is a remarkable cure.

are distributed over the scalp collapse and subsequently become inconspicuous.

The type of treatment of these aneurysms depends on whether or not the arterial coil is (1) extracranial or (2) intracranial, if extracranial, removal of the mass will produce a cure, if intracranial, removal of the group of vessels emerging from the skull will cure the extracranial aneurysm, but the primary coils in the dura will continue to cause headache. For the cure of the intracranial angiomatous mass, a semicircular flap of scalp is turned down so as to expose the entire group of vessels emerging from the bone in the involved area. The bone is scraped and waxed, or, as in the other group when the arterial

supply to the scalp is eliminated the pulsating vessels in the scalp will collapse

The excision of an angiomatous mass (coil of vessels) that is entirely extracranial (as case 3) is relatively simple. This can be done with (1) a semicircular flap around the angiomatous mass or (2) a straight incision over its center. In either case the mass of vessels is isolated from the scalp and dissected from the skull or scraped from the skull and the entering vessels waxed. Should the tumor invade the skin (as in case 3), a straight incision is preferable because the affected area of skin should be excised. Since the skin is redundant, the edges can be brought together without leaving a defect in the scalp. In 10 of the cases collected from the literature a flap has been used and in 5 a straight incision, at times with a counterincision (Parker, 1904). On the whole, the flap is easier, but if the aneurysm is over the forehead a straight incision will leave a smaller scar.

Ligation of one or both external carotid arteries is hardly advisable and is not necessary for an aneurysm in the scalp, since the bleeding is not difficult to control. Ligations of the common or the internal carotid arteries are never indicated and are strongly contraindicated. Ligation of both the external and the internal carotid arteries on one side, however, is essential for such aneurysms as those in the eyelids, as presented in case 1, both vessels contributed to its arterial supply because of the extensive collateral circulation between these vessels in the orbit. It is doubtful that this lesion could have been extirpated without these ligations. And the better time to complete the removal of an aneurysm of this type is immediately after the arteries have been ligated, delay means return of some pulsation.

If an extracranial aneurysm has been completely removed it probably will not recur. If only partially removed, it will recur unless a fortunate and hardly to be expected progressive thrombosis obliterates the aneurysmal mass.

It is not clear how far one should go in the treatment of the aneurysms with the vascular coils in the dura, from which the aneurysms of the brain and the scalp are supplied. Certainly nothing can be accomplished toward removal of the intracerebral aneurysm, extensive coagulation of the varices of the middle meningeal arteries has been done in these cases, and, I believe, with benefit. Whether or not the extracranial aneurysm would recur unless the dural vessels are also obliterated is not certain, though I should suspect that it might well do so. It seems hardly possible that the headaches would be cured without elimination of the dural vessels. It has seemed advisable to attack the dural vessels in order to increase the probabilities of success. This entails practically no risk, but it does leave a defect in the skull (which, of course, can be corrected later if desired) the skull must

be removed piecemeal, since a bone flap would not be safe with such profuse bleeding. In no other condition is the skull so vascular, not even with dural meningiomas.

It might well appear that the large intracerebral aneurysm would be the source of the headache. This was true in case 7, but many similar arteriovenous aneurysms, without dural connections, have been found at operation and have not caused headache.³¹ Moreover, removal of the dural and the extradural vessels does stop the headache in most instances.

It is also difficult to determine whether the aneurysms should be attacked on one or both sides when they are known to be bilateral. My judgment has been to operate on one side only when the headache or noise is unilateral and to operate on both sides when the symptoms are bilateral.

SUMMARY

Seven, and probably 8, of the 9 cases of arteriovenous aneurysm of the scalp and face presented are of congenital origin, in 1 the aneurysm followed trauma late in life, and there was no known pre-existing angiomatous lesion. This percentage of congenital aneurysms is approximately in accord with the incidence of such lesions from the cases in the literature. Similar aneurysms in the integument occur elsewhere over the body but less frequently than in the scalp.

In all the 7 cases of aneurysms in the scalp, the arterial supply was traced to the middle meningeal arteries and was therefore of intracranial derivation. In 1 the arterial supply was through two arteries, one on either side, and continuous with the greatly enlarged middle meningeal arteries through the parietal foramina (roentgenologically). In the other 6 there were numerous branches perforating the bone on both sides and derived from great primary plexuses of vessels in the dura (the middle meningeal arteries). In these cases, the roentgenograms disclosed greatly widened grooves of the posterior branches of the middle meningeal arteries, and these were directed to the parieto-occipital region, in which the extracranial arteriovenous aneurysms appeared. In 1 case the anterior branch of the middle meningeal was enlarged and supplied a frontal aneurysm of the scalp.

Three of the aneurysms (all with hemianopsia) were demonstrated at operation to be in the brain—one in the frontal and temporal, one in the temporal and parietal and one in the parietal and occipital lobes. In 2 other cases with hemianopsia, the brain was not exposed, but intracerebral aneurysm was doubtless the cause of the hemianopsia.

In 4 cases, there were occasional convulsions, indicating a cerebral lesion, but in 1 of these the convulsions were not due to the aneurysm.

³¹ Dandy, W. E. Arteriovenous Aneurysms of the Brain, *Arch. Surg.* **17** 190, 1928.

but to another congenital lesion, i. e., three closely related bony spicules in the sensory leg area. These aneurysms, therefore, may involve the dura and the brain, in addition to the scalp, the arterial supply has been from the middle meningeal artery in all of the cases. Although in all except 1 of our cases the extracranial aneurysms were bilateral, many of the cases assembled from the literature involved only one side of the scalp.

The safest and best treatment of the aneurysms when an extracranial primary angiomatous mass exists is extirpation of the central mass, the large pulsating veins that radiate from the mass disappear when the source of the arterial blood is removed. When the primary angiomatous mass is in the dura, the vessels penetrating the bone should be waxed after the scalp has been stripped from the affected area of bone. It is probably better in these cases to expose and coagulate the dural varices and to ligate one or both (if bilateral) of the middle meningeal arteries.

Many good results have been obtained by injecting sclerosing solutions into the central mass, there may be times when this has an advantage, i. e., when the aneurysm is over the forehead and a scar would be averted or when excision of one in the ear would mean sacrificing part of the ear. Injections are probably more dangerous and are less certain than operation when the latter is performed by a good surgeon, cures from injections are due to thromboses that propagate from the venous into the arterial component of the aneurysm. In the presence of an intracranial aneurysm sclerosing injections might well be hazardous.

Ligation of the external (not the common) carotid artery is usually not necessary as a preliminary procedure to reduce the arterial content of aneurysms of the scalp. In our case, however, the extirpation of the aneurysm in the eyelids would have been hazardous without ligations of both the internal and the external carotid arteries, both of which contributed to its pulsation because of the extensive anastomoses. Ligations of the arteries in the scalp are useless because they do not supply the aneurysm.

PILONIDAL SINUS AND CYST

A Clinical Study

F J BURNS, M D
ST LOUIS

THIS clinical study presents a survey of 240 cases of pilonidal sinus and/or cyst encountered at St Mary's Hospital Group of Hospitals of St Louis University School of Medicine from the time each hospital of the group was opened (St Mary's Hospital 1924 and Firmin Desloge Hospital 1933) until October 1943. There is a total of 240 cases, 130 at St Mary's Hospital and 110 at Firmin Desloge Hospital. The cases were studied in detail, and the results are as indicated in this paper.

The literature on the subject contains many papers, especially those dealing with the cause and the treatment of the condition,¹ and a short discussion of the current views on the subject is presented.

From the St Louis University School of Medicine

1 Biegeleisen, H I Sclerotherapy for Pilonidal Cyst, *Am J Surg* **44** 622-625, 1939 Breidenbach, L, and Wilson, H L Pilonidal Cysts and Sinuses, *Ann Surg* **102** 455-463, 1935 Dunphy, J E The Operative Treatment of Pilonidal Sinus, *Surgery* **2** 581-584, 1937 Glenn, F Pilonidal Sinus, *New England J Med* **207** 544-546, 1932 Hadley, H G Pilonidal Cysts and Sinuses, *M Times, New York* **68** 322-323, 1940 Hamby, W B Pilonidal Cyst, Spina Bifida Occulta and Bifid Spinal Cord, *Arch Path* **21** 831-838 (June) 1936 Johnson, W J, and Livingston, A G The Incidence of Pilonidal Sinuses in Mental Defectives, *J Nerv & Ment Dis* **87** 156-158, 1938 Kallet, H I Pilonidal Sinus, *Am J Surg* **50** 648-652, 1940 Kooistra, H P Pilonidal Sinuses Review of Literature and Report of 350 Cases, *ibid* **55** 3-17, 1942 McKirdie, M Pilonidal Sinus, *Ann Surg* **107** 389-399, 1938 Pickett, W J, and Beatty, A J Pilonidal Cysts in the Army, *Am J Surg* **56** 375-378, 1942 Rogers, H Pilonidal Sinus, *Surg, Gynec & Obst* **57** 803-810, 1933 Sharpe, A M Pilonidal Sinus, *Am J Roentgenol* **38** 303-307, 1937 Smiley, K E Pilonidal Sinus, *Am J Surg* **27** 298-301, 1935 Smith, N D Common and Rare Sinuses or Fistulas, Which Occur in the Anus or Near the Anus, *S Clin North America* **19** 1021-1032, 1939 Swinton, N W, and Hodge, C C The Treatment of Pilonidal Sinus, *ibid* **19** 699-708, 1939 Stone, H B The Origin of Pilonidal Sinus, *Ann Surg* **94** 317-320, 1931 Tendler, M J Pilonidal Sinus Review of the Literature and Report of Eighty-Seven Cases, *South M J* **34** 1156-1168, 1941 Weeks, R B, and Young, G G Sacrococcygeal Cysts, *Am J Surg* **60** 260-263, 1943 Weinstein, M Pilonidal Sinus, *Ann Surg* **97** 80-84, 1933 Whyte A H Post-Anal So-Called "Pilonidal" Sinus, *Proc*

(Footnote continued on next page)

DEFINITION

According to Bacon,² a pilonidal sinus is a congenital defect in the midline over the sacrococcygeal region, characterized by the formation of a tract in which are collected the by-products of dermal activity, with a tendency to burrow and undergo abscess formation

The most generally used, and accepted, name is that of "pilonidal" sinus (or cyst), which means a "nest of hair" (Latin), but not all lesions contain hair. The name is therefore regarded more or less as a misnomer.

Synonyms include such names as pilous cyst, sacral, coccygeal or sacrococcygeal infundibulum, dermoid, dermoid fistula sinus or cyst, posterior umbilicus, postanal dermoid, congenital dermal sinus, sacrococcygeal ectodermal sinus, sequestration, coccygeal, postsacral traction dermoid, and foveola coccygea.

INCIDENCE

Pilonidal sinus is encountered in both sexes and in all age groups but is most commonly found in young adult males of the pituitary type, tall and obese, with broad hips and hairy bodies.

It is strikingly confined to the Caucasian race, and no reports have mentioned the occurrence of the lesion in the red, the yellow or the brown races. Only a few cases of its occurrence in Negroes have been reported, and Saleeby and McCarthy,³ who reported 1 such case, stated the belief that the low incidence is due to the negroid pigmentation, which either inhibits the activities of the living cells of the sinus or neutralizes their products by chemical action.

In this series, 163 of 240 patients were men and 77 were women, a ratio of slightly more than 2:1. The average age of the men was 26.2 years and of the women 22.1 years. The oldest patient was 61 years, while the youngest was a newborn infant (2 cases).

ETIOLOGY

The condition is not hereditary, but cases of its occurrence in several members of the same family have been reported. Numerous theories have sought to explain the origin of the lesion, but no one theory is generally agreed on. However it is generally agreed that the lesion is congenital.

Roy Soc Med **31** 982-984, 1938. Woldenberg, S. C., and Sharpe, W. S. Surgical Treatment of Pilonidal (Dermoid) Cysts, Surg., Gynec. & Obst. **76** 164-170, 1943. Wolff, J. P. Pilonidal Cyst, South. M. J. **32** 1243-1245, 1939.

2 Bacon, H. E. Anus, Rectum, Sigmoid Colon. Philadelphia, J. B. Lippincott Company, 1941.

3 Saleeby, E., and McCarthy, P. A. Pilonidal Sinus in a Negro, Ann. Surg. **105** 634-635, 1937.

The two prevalent theories as to the causation of pilonidal sinus are (1) that which traces the origin of the condition to a remnant of the neurenteric canal and (2) that which derives the lesion by a process of ectodermal invagination. Investigators who uphold the former theory are in the majority.

The neural theory considers the pilonidal sinus formation as an anlage of development of the neural canal. The ectoderm posterior to the primitive groove thickens and forms two neural folds. These meet in the midline and cone outward posteriorly forming an opening for the neural groove. This groove should close at the end of six months and when it remains patent such malformations as spina bifida (occulta or externa) result. This entire area is of course, adjacent and adherent to the bony structure of the body, so that the formation of a sinus tract can readily be understood as the bony parts grow more rapidly than the skin, and if there is attachment to either the ectodermal rests become stretched into a sinus tract.

As the neural folds coalesce and pinch off from the overlying ectoderm to form the neural cord and canal, ectoderm, and even a well formed sinus tract may remain behind. This tract may be closed at one or both ends hence there results a single isolated cyst, a sinus closed at one end or open at either end or even one communicating with the spinal canal.

Neural buds have been reported in some of the pathologic specimens and meningitis has been reported as having originated from an infected pilonidal cyst. Spinal fluid has been seen to escape during the excision of a sinus tract.⁴

Gage⁵ has studied serial sections of the human fetus and has stated the belief that the true pilonidal sinus and cyst are due to the persistence of the neurenteric canal and are divisible into four groups: (1) sacrococcygeal dimple and sacrococcygeal dimple sinus, (2) true pilonidal sinus, confined to the subcutaneous tissue, (3) true pilonidal sinuses extending into the sacral canal and (4) true pilonidal sinuses which are continuous with the subarachnoid space and canal of the spinal cord.

Studies were also made on the human embryo by Fox,⁶ who supported the ectodermal invagination theory and presented evidence which indicates

1 That pilonidal sinus is a derivative of skin ectoderm and not neurogenic or enteric in origin.

4 Zieman S. A. Pilonidal Cysts. *Surg, Gynec & Obst* **66** 231-235 1938.

5 Gage M. Pilonidal Sinus, *Arch Surg* **31** 175-189 (Aug.) 1935, Pilonidal Sinus, *Tr South S A* **50** 52-71, 1937, Pilonidal Sinus, *Ann Surg* **109** 291-303, 1939.

6 Fox, S. L. The Origin of Pilonidal Sinus, *Surg Gynec & Obst.* **60** 137-149, 1935.

2 That the structures forming the sinus are derived by a process of ectodermal invagination from the skin surface at the time and in the cells destined to form skin appendages (hair and glands) during the third and fourth months of embryonic life

3 That its mode of origin, and the analogy drawn between this structure and the special "scent" gland in the sacrococcygeal region of birds and amniotes, suggest the probability that the sinus represents a vestigial skin appendage developing at puberty—hence the age distribution of pilonidal sinuses

4 That coccygeal medullary vestiges exist is not denied, but they do not give rise to the pilonidal sinus. They probably give rise to the large cystic and solid tumors which occur usually in infants and the newly born. There is also the possibility that they may play a role in the upward direction which the pilonidal sinus takes

PATHOLOGY

A pilonidal sinus is usually seen as a very small rounded aperture situated in midline in the skin over the sacrum, the coccyx or the junction of the two. Often a few hairs protrude through the orifice. The tract leads slightly upward through the subcutaneous tissue and ends in a blind pouch or cystic cavity of varying size. Arborization may be produced by epithelial branching. These sinuses may be single, with one external opening, or many external openings may be present. The sinus may extend unilaterally or bilaterally up into the groin or down into the leg. Inwardly, it may communicate with the presacral fascia extend directly through and into the vertebral canal and even become continuous with the periosteum or the meninges.

Microscopically, the sinus tract is lined with stratified squamous epithelium. The cyst cavity, when present, is lined with the same type of epithelium or with stratified cuboidal epithelium. Sweat glands, hair follicles, hair and occasional neural buds are present. There is a dense chronic inflammatory cell infiltration in and about the sinus or cyst wall, which is surrounded by fibrous tissue and fat. The cyst cavity and the lumen of the sinus tract usually contain debris and pus.

There is no communication with the rectum nor is any endodermal tissue found.

Malignant changes in a pilonidal sinus or cyst have not been reported in the literature to date.

In 217 of the cases under discussion, tissue was removed for gross and microscopic examination. Of the lesions, 111 were described as being sinuses and 106 as being definitely cystic, *i. e.*, having a demonstrable cavity though no definite epithelial lining was described. Hair was present in 10 of the sinus specimens and in 44 of the cystic specimens, making a total of 54. Therefore, 25 per cent of the 217 specimens contained gross or microscopic evidence of hair. Though

epithelial elements were described in almost every case, no mention was made of any nerve tissue being present

SYMPTOMS

The lesion is without symptoms until infection has taken place. Trauma is almost invariably the inciting factor. However, falling and striking the coccygeal region, long and frequent automobile rides, horse-back riding and direct violence (often in the course of some sport) are most frequently cited as preceding the onset of the symptoms. It has been referred to as the "jeep disease" by Buie⁷ in a recent article, because of the frequency of the lesion in the military service.

Following trauma, infection takes place, usually with a *Staphylococcus*, though *Bacillus coli* is not an infrequent contaminator. The infection results in a chronic discharge, with pain and tenderness in the part. Abscesses often form, and these require drainage. The discharge consists of sebaceous material, epithelial debris and pus, which sometimes irritates and causes a pruritus.

At times, a dull ache is present in the lower part of the back, but constitutional symptoms are rare.

Pain and discharge were the two commonest symptoms encountered in this series of cases, and the average duration of the symptoms was 2.6 years. Pain was present in 133 cases, discharge in 198 cases and both pain and discharge in 102 cases.

DIAGNOSIS

The diagnosis is made on the history of the case and the presence of one or more small sinus openings, usually located in the midline over the sacrococcygeal region. A small tuft of hair frequently protrudes from the orifice of the sinus. The skin about the sinus opening is usually reddened, and a thin seropurulent discharge exudes from the orifice. A probe is readily passed into the sinus tract, usually in an upward direction.

A roentgenographic examination of the sinus following injection of an opaque substance has been advocated, usually as a preoperative procedure, to determine the extent and direction of the sinus tract or tracts. In only 1 case in this series was this procedure used.

In 159 cases in the series, one sinus tract was present; in 35 cases two sinus tracts were present; in 13 cases three sinus tracts were present, and in 17 cases more than three tracts were present. Thus in 224 of 240 cases there were sinus tracts. A scar is described as having been present in 5 cases, and no mention is made of any sinus (or scar) in 11 cases.

⁷ Buie, L. A. Jeep Disease (Pilonidal Disease of Mechanized Warfare), *South M J* **37** 103-109, 1944.

DIFFERENTIAL DIAGNOSIS

Pilonidal sinus is to be differentiated from other conditions that occur about the sacrococcygeal region, such as tuberculosis, syphilis, osteomyelitis of the coccyx or sacrum, anal or rectal fistulas, sebaceous cysts, pyogenic infections, presacral dermoids ischiorectal abscesses, carbuncle of the buttocks, lipomas, teratomas, fetal implantations, traumatic dermoids implantation cysts, anthrax and actinomycosis

TREATMENT

The treatment of pilonidal sinus has received much attention because of the long period of healing required by some methods and because of the frequency of recurrence of the lesion. Many forms of treatment are advocated, but radical excision gives the greatest percentage of permanent cures.

Conservative treatment includes hot sitz baths, cauterization of the sinus tract with phenol, silver nitrate, nitric acid or other caustic agents, simple incision with packing of the cavity with iodoform gauze or repeated swabbing with tincture of iodine. All these methods give considerable relief of symptoms for periods of days and sometimes months.

Cutler and Zollinger suggested a modification of Carnay's solution as a sclerosing solution: this consists of absolute alcohol, 6 cc, chloroform 3 cc, glacial acetic acid, 1 cc, and ferric chloride 1 Gm. They reported good results from use of this solution.

Rogers and Hall⁸ recommended repeated excisions with cauterization of the diseased tissue only, carried out as minor operations on ambulatory patients.

Block and Greene⁹ have treated a small group of patients by means of simple incision and application of a sclerosing solution and results were good.

Turell¹⁰ advocated radiation therapy as a substitute for operation for the recurrence of infected sacrococcygeal sinus, and Smith¹¹ stated the belief that roentgen radiation given preoperatively and postoperatively is a definite adjunct in the treatment of pilonidal sinus.

That radical elliptic excision of all the diseased tissue down to the fascia covering the sacrum is the method of choice is rather generally

8 Rogers, H. and Hall, M. G. Pilonidal Sinus. *Arch Surg* **31** 742-766 (Nov) 1935.

9 Block, L. H. and Greene, B. L. Pilonidal Sinus. Sclerosing Method of Treatment, *Arch Surg* **37** 112-122 (July) 1938.

10 Turell, R. Radiation Therapy for Recurrent Sacrococcygeal Cysts and Sinuses. *Surgery* **8** 469-472, 1940.

11 Smith, R. M. Roentgen Irradiation as Adjunct to Surgical Treatment of Pilonidal Cyst. *Am J Roentgenol* **38** 308-311, 1937.

agreed on but the method of treating the wound varies as is indicated in the following paragraphs

Various dyes, especially methylthionine chloride and gentian violet medicinal, are sometimes injected into the sinus tract prior to excision as an aid in identification of the diseased tissue. This was done in many of the cases in this series, but it is not a necessary procedure, because it is usually not difficult to differentiate between normal and abnormal tissue and again, the dye often infiltrates and stains the tissue surrounding the sinus or cyst wall.

Weeder¹ advocated excision of the coccyx in cases in which roentgenologic examination of a sinus tract injected with iodized poppyseed oil or other substance opaque to roentgen rays shows the tract to invade the sacrococcygeal joint, in cases in which after a careful injection with methylthionine chloride a discoloration at the sacrococcygeal joint is shown, and in cases in which the character of the tissue about the sacrococcygeal joint is under suspicion. He argued that a remnant of the cyst wall is contained within the sacrococcygeal joint as an unobliterated portion of the medullary canal.

No palliative measures were employed in the treatment of any of the patients while in the hospital. Patients not treated, including 2 newborn infants, were in the hospital for treatment of some other condition. Incision and drainage was done for those patients with associated acute abscess.

The various methods of treatment used in this series of cases are as follows: (1) excision, wound left open with gauze pack, (2) excision, closure with secondary sutures, (3) excision, partial primary closure with pack, (4) excision, primary closure with drain, (5) excision, complete primary closure, (6) excision, pedicle flap method with primary central closure, (7) excision, with lateral incision and double primary closure, (8) marsupialization, (9) opening, curettement and packing of the lesion, (10) incision and drainage.

The table indicates the number of patients treated with each method, the number followed and the number cured.

Several anesthetics were employed. The various types and the number of cases in which each was used are shown in table 2. In 9 cases, the type of anesthetic was not indicated.

An attempt was made to follow up each patient, but owing to change of address, change of name or other circumstances, a large percentage of patients could not be properly followed. The few exceptions previously mentioned include the patients who did not undergo radical treatment for the condition and so were not followed. To the

patients who did not return to the hospital for further treatment of a recurrence, a questionnaire was mailed. This was returned by the patient, with answers to questions as to any further local pain, swelling or discharge following operation and discharge from the physician's care. Needless to say, not all questionnaires were returned. In many

TABLE 1—*Types of Treatment for Patients with Pilonidal Sinus and Cyst, with Number of Operations and Number Cured*

Type of Operation	Num- ber of Patients	Pa- tients fol- lowed	Cured with 1 Operation		Cured with 2 Operations		Cured with 3 Operations		Total Cured	
			No	%	No	%	No	%	No	%
Excision wound open with pack	106	65	47	72	6	9.2	1	1.5	54	86
Excision closure with secondary suture	2	1	1	100					1	100
Excision partial primary closure with pack	6	6	5	83	1	17			6	100
Excision primary closure with drain	36	22	10	59	2	9			15	68
Excision complete primary closure	63	43	30	70	4	9			34	79
Excision, closure with pedicle flap	2	2	0	0	2	100			2	100
Excision lateral incision and closure	3	3	3	100					3	100
Marsupialization	1	1	1	100					1	100
Lesion opened, curetted, packed	2	1	1	100					1	100
Incision and drainage	5	0	0	0					0	0
Not treated	9	0	0	0					0	0
All types (totals)	240	144	101	70	15	10	1	0.7	117	81
Corrected for incision and drainage and not treated	223	144	101	70	15	10	1	0.7	117	81

TABLE 2—*Types of Anesthetics Used*

Anesthetic	Number of Cases
Spinal	113
Gas (nitrous oxide, ethylene or cyclopropane)	60
Ether	11
Gas and ether	2
Local (procaine hydrochloride infiltration)	19
Evipal sodium	1
Total	212

cases, therefore, the criteria of a recurrence of the lesion once it had been excised lay in the patient's interpretation of and answers to these questions.

Gage⁷ stated that recurrence of the condition is due to one or more of the following causes: (a) Presence of infection in both primary sinuses and primary cysts, as well as in secondary sinuses, (b) failure to obliterate dead space at the time of primary suture of the wound, and

(c) failure of complete removal of the epithelium-lined pilonidal sinus and accessory sinus tracts

A total of 34 patients had acutely inflamed pilonidal sinuses. In 1 case the lesion was opened, curetted and packed with gauze. In 8 cases of abscess incision and drainage were done. In the remaining 25 cases, the lesion was excised and predominantly acute inflammatory reaction was observed on microscopic examination of the removed tissue. Of these 25 cases, there were recurrences in only 3, thus 88 per cent of the patients in these cases were cured. It would seem from this that infection (the most common cause of acute inflammation in a pilonidal lesion) had but little to do with recurrences in this particular series of cases.

CONCLUSIONS

1 Radical excision of all the diseased tissue down to the fascia covering the sacrum is the method of choice in the treatment of pilonidal sinus and/or cyst.

2 The lesion is prone to recur, as is evidenced by the fact that in only 70 per cent of the cases followed was cure effected by one operation.

3 By far the great majority of patients are cured by two operations (only 1 patient required three operations).

4 A total of 81 per cent of patients were cured by use of various methods of treating the defect resulting from excision of the lesion.

5 The most effective type of operation, and the one most frequently used, was that of leaving the wound open for granulation.

6 Of the patients with associated acute inflammation, 88 per cent were cured. Acute inflammation, therefore, does not influence the ratio of recurrence.

EFFECT OF INTRAVENOUS ADMINISTRATION OF OXYGEN ON SHOCK IN DOGS AND IN HUMAN BEINGS

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THAT anoxemia is an important factor in the pathogenesis of traumatic shock has long been recognized¹ Experimental² and clinical³ investigations have yielded encouraging results in combating such shock by the inhalation of high concentrations (100 per cent commercial) of oxygen Boothby and his collaborators³ expressed the opinion that the use of such high concentrations of oxygen resulted in a significantly greater degree of recovery than when the usual 95 per cent oxygen and 5 per cent carbon dioxide inhalant mixture was employed The additional 5 per cent oxygen yielded an increase of 22 cc of oxygen per hundred cubic centimeters of blood Small though the increase be it causes a rise in oxygen saturation of capillary and venous blood in cases of shock from 20 per cent saturation to 33 per cent

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† Dr Jennings, chief surgeon of the Beth-El Hospital, died on May 25, 1945

1 Moon, V H Shock and Related Capillary Phenomena, New York, Oxford University Press, 1938, pp 167-172 and 361-370 Blalock, A Principles of Surgical Care Shock and Other Problems, St Louis, C V Mosby Company, 1940, pp 129, 132, 137 and 141

2 Wood, G O, Mason, M F, and Blalock, A Studies on Effects of Inhalation of High Concentrations of Oxygen in Experimental Shock, Surgery 8 247, 1940 Schnedorf, J G, and Orr, T C (a) Beneficial Effects of Oxygen Therapy in Experimental Traumatic Shock, Surg, Gynec & Obst 73 79, 1941, (b) Beneficial Action of Oxygen Therapy in Experimental Shock, *ibid* 73 301 1941, (c) Oxygen Therapy in Shock Due to Hemorrhage, *ibid* 73 495, 1941

3 Boothby, W M, Mayo, C W and Lovelace, W R One Hundred Percent Oxygen Indication for Its Use and Methods of Its Administration, J A M A 113 477 (Aug 5) 1939

saturation The oxygen partial pressure rises from 14 to 21 mm, with an equivalent rise of 50 per cent of oxygen pressure in the tissues The net result is a striking increase in oxygen available to the tissues³

Several attempts have been made in the past to administer gaseous oxygen intravenously⁴ All were discontinued because of the development of such undesirable effects as embolism or cardiac tamponade An analysis of these attempts shows that the amounts of oxygen administered were too large or that the gas was injected too rapidly or at too high a pressure Despite the fact that physiologists had long administered gaseous oxygen intravenously to animals without harm,⁵ so ingrained has been the clinician's fear of air embolism that attempts at using oxygen intravenously were regarded as curios and dropped after brief and generally incomplete study That air embolism is not so common as a review of medical texts would lead one to believe is evidenced by the records of the Office of the Chief Medical Examiner of the city of New York Thus, in over 150,000 autopsies in cases of a wide variety of diseases with conditions favorable to the development of air embolism, only 20 cases of this condition are recorded⁶ All occurred when air—not oxygen—was forcibly and rapidly injected into hollow viscera (tubal insufflation, aerograms of the bladder in cases of ulcerated carcinoma and other methods) and rapidly entered the circulation Of the untold numbers of intermittent and continuous procedures in intravenous administration in daily medical use, air embolism is apparently so rare a complication as to be recorded in isolated case reports⁷

It must further be emphasized that air and oxygen are not at all comparable from the standpoint of intravenous administration Atmospheric air contains 20.94 volumes per cent of oxygen, 0.04 volume per cent of carbon dioxide and 79.02 volumes per cent of nitrogen

4 Mariani, F Le iniezioni endovenes di ossigeno nell' uomo, *Riforma med* **18** 194, 1902 Tunnichiffe F W, and Stebbing, G F The Intravenous Injection of Oxygen as a Therapeutic Measure, *Lancet* **2** 321, 1916 Singh, I, and Shah, M J Intravenous Injection of Oxygen, *ibid* **1** 922, 1940

5 Nyssen, P H Recherches de physiologie et de chimie pathologiques, Paris, J A Brosson, 1811 cited by Demarquay J N Essay on Medical Pneumatology Physiological Clinical and Therapeutic Investigation of the Gases translated by S W Wallian, Philadelphia, F A Davis Company, 1889, pp 75-82 Gaertner, G Ueber intravenöse Sauerstoffinfusionen, *Wien klin Wchnschr* **15** 691, 1902 Stuetz, E Ueber intravenöse Sauerstoffinfusionen, *Ztschr f diätet u physik Therap* **7** 67, 1904 Bourne, G and Smith, R G The Value of Intravenous and Intraperitoneal Administration of Oxygen *Am J Physiol* **82** 328 1927 Dick M The Respiratory and Circulatory Responses to Intravenous Oxygen and Their Relation to Anoxemia *Am J Physiol* **127** 228 1939

6 Gonzales T A Personal communication to the authors

7 Terplan K and Javert C T Air-Embolism Following Intravenous Drip *Am J Path* **11** 880 1935

(including 0.94 volume per cent of argon and other rare gases) ⁸ Thus its greatest components are irrespirable gases. In perfectly normal respiration from 4 to 6 per cent of the inspired atmospheric oxygen is utilized ⁸ Oxygen, per contra is entirely respirable. If given intravenously at a slow rate and at pressures not substantially greater than venous pressure, it should exert far more potent physiologic effects than when inhaled and in comparatively minute quantities.

Ziegler ⁹ in 1941 described an apparatus for administering pure oxygen intravenously at low pressures and in physiologic amounts and mentioned its use by this route for several patients. He noted no deleterious effects but gave no details of the results. Using Ziegler's apparatus with minor modifications we have studied the effects of intravenously administered 100 per cent (commercial and U. S. P.) oxygen in animals with experimentally induced toxic shock and in 3 human beings with severe acute progressive (secondary traumatic) shock ¹⁰

EXPERIMENTAL STUDIES

In 12 dogs a shocklike state, to complete coma, was produced by the intravenous injection of a saline extract of dog muscle as suggested by Moon ¹¹ The dose given

Effect of Intravenous Administration of Plasma and Oxygen on Experimental Shock in Dogs

Dog	Weight, Kg	Dose Muscle Ex tract, Gm	Initial Blood Count, Million R. B. C. / Cu. Mm. Average 4 Days	Blood Count, Beginning Treatment, Million R. B. C. / Cu. Mm.	Hemo-concentration, %	Treatment	Final Blood Count, Million R. B. C. / Cu. Mm.	Result
1	11.4	80	5.1	7.7	50	None	8.5	Death, 7 hr
2	11.2	80	5.0	7.6	52	None	8.1	Death, 7 hr
3	11.0	78	4.8	7.7	60	None	8.0	Death, 5 hr
4	11.4	80	5.0	7.2*	44	300 cc plasma	7.8	Death, 10 hr
5	11.6	81	5.3	7.8*	47	500 cc plasma	8.1	Death, 11 hr
6	11.5	80	5.1	7.0*	47	400 cc plasma	8.6	Death, 11 hr
7	11.4	80	5.0	7.6*	52	400 cc oxygen	6.5	Death, 17 hr
8	11.5	80	5.0	7.7*	54	2,100 cc oxygen	5.4†	Recovery
9	11.0	78	5.0	7.9*	58	1,800 cc oxygen	5.2†	Recovery
10	11.1	80	5.0	7.0*	52	2,800 cc oxygen	5.4†	Recovery
11	11.0	80	4.8	8.0*	66	2,700 cc oxygen	6.2†	Recovery
12	11.3	82	5.2	8.9*	70	2,500 cc oxygen	5.0†	Recovery

* Count not lower than 40 per cent concentration for four hours before treatment was begun

† Count not higher than this level for four hours before oxygen was discontinued

8 Best, C. H., and Taylor, N. B. *The Physiological Basis of Medical Practice*, ed 2, Baltimore, Williams & Wilkins Company, 1940, p. 511

9 Ziegler, E. E. *The Intravenous Injection of Oxygen* J. Lab. & Clin. Med. 27: 223, 1941

10 Richards, D. W., Jr. *The Circulation in Traumatic Shock in Man*, Bull. New York Acad. Med. 20: 363, 1944

11 Moon,¹ p. 189

was the extract equivalent of 7 Gm of muscle per kilogram of body weight, a dose previously shown by Moon and confirmed by our experience to induce an irreversible shocklike state and death of the animal. When the hemoconcentration had remained at or above the critical level of 40 to 50 per cent for at least four hours, 3 dogs were given 300 to 500 cc of dog plasma intravenously and 5 were given 100 per cent (medicinal) oxygen intravenously continuously for between ten and fourteen hours at the rate of 100 cc per hour—i.e., until the capillary blood count had returned to the level existing before the muscle extract was administered—and had remained at this level for four hours. Early in the experiment, 1 such dog received oxygen intravenously for three hours, with a drop in hemoconcentration to 30 per cent, at which time the oxygen was discontinued. This dog subsequently had a relapse and died. Three dogs in a deep shocklike state were not treated. The results are summarized in the table.

The untreated and the plasma-treated dogs and the 1 incompletely treated with intravenous administration of oxygen all died, the last surviving six hours longer than those of the other two groups. At autopsy, well marked parenchymal congestion and hemorrhages, extremely viscid venous blood and poorly filled vessels were found, conditions similar to those found by Moon.¹² The 5 dogs receiving oxygen intravenously for long periods survived and were well until killed between the third and the twenty-first day after the experiment, at which time the only evidence of the antecedent shocklike state was the presence of fading parenchymal, chiefly colonic mucosal, hemorrhages of increasing age and diminishing extent. No evidence of air embolism or tamponade was noted clinically or at autopsy in any dog.

REPORT OF CASES

CASE 1—J. G., a 60 year old white man, was admitted to Beth-El Hospital on July 10, 1942, with a history of progressive loss of weight, anorexia and vomiting of six months' duration. He was extremely cachectic, weighing 85 pounds (38.6 Kg.). His abdomen was scaphoid, and tenderness was present in the right upper quadrant and epigastrium, no masses were palpable. Roentgen ray examination showed an annular canalization of the midportion of the stomach, involving the major part of the pars media, with a wide contracture of the greater curvature, there was a residue of 90 per cent of the ingested barium sulfate after six hours, with a few specks of barium in the ileum. His red cell count was 2,800,000 per cubic millimeter, and his hemoglobin content was 50 per cent (Sahli). Despite three blood transfusions (2,000 cc.), the red cell count rose only to 3,100,000 and the hemoglobin content to 53 per cent. His preoperative blood pressure was 108 mm of mercury systolic and 64 mm diastolic. Though he was considered a poor operative risk and the carcinoma was deemed far advanced and probably inoperable, the patient insisted on operation stipulating further that every attempt be made at resection of the tumor.

With the patient under fractional spinal procaine hydrochloride anesthesia, a difficult subtotal gastrectomy was performed on July 20. The stomach was adherent to the colon, small intestines and liver, but there was no apparent neoplastic involvement of these viscera.

One hour after the operation was begun (at which time he had received 75 mg of procaine hydrochloride), considerable thirst developed. His skin became moist and cold and his color pallid. He retched and vomited several times. At first restless, he became progressively apathetic and then lapsed into coma. His blood pressure, which, with continuous transfusion from the start of the operation, had initially

fallen to 80 mm. of mercury systolic and 60 mm diastolic and returned to 104 mm systolic and 70 mm diastolic, now began to fall progressively, despite the continuing transfusion and the administration of epinephrine, nikethamide and caffeine and sodium benzoate and of oxygen by inhalation. One and three-quarters hours from the beginning of the operation he was pulseless his blood pressure was unobtainable and his lungs were full of coarse rales. His heart sounds were extremely feeble and exceedingly rapid. A small amount of extremely viscid blood exuded from veins as they were severed, the surgeon commenting that the vessels were "empty." The lips and face were chalky white and bloodless. The cell volume by hematocrit reading at this time was 72 per cent. The specific gravity of the capillary blood was 1.0704 (normal 1.0566).

At this point all other medication and the transfusion were discontinued and intravenous administration of 100 per cent oxygen was started at a rate of 600 cc. per hour. After the oxygen had been flowing for eleven minutes, the blood became bright pink and fluid, it flowed in considerable amounts as veins were severed. The surgeon, in fact, was greatly surprised at the fulness of the veins. Fifteen minutes after the intravenous administration of oxygen had been begun, the patient regained consciousness. His blood pressure at this time had risen to 98 mm. of mercury systolic and 62 mm diastolic, the pulse rate was 88 per minute, the pulse was of good quality and regular and the heart sounds were distinctly audible and of good quality. His lungs now showed only a few rales, and even these had disappeared within a few more minutes. The cell volume by hematocrit reading had diminished to 61 per cent. The specific gravity of the capillary blood had fallen to 1.0640. Despite the further administration of 100 mg. of procaine hydrochloride in four divided doses intraspinally during the succeeding ninety minutes that the operation consumed and despite considerable manipulation necessitated by the separation of the adhesions the patient's color, venous filling, alertness and blood pressure remained unchanged. The oxygen was continued intravenously throughout the remainder of the operation, no other adjuvant therapy was employed. The cell volume by hematocrit reading had further diminished to 56 per cent, and the specific gravity of the capillary blood had further fallen to 1.0593.

When the patient had been returned to the ward after three and one-half hours in the operating room, the intravenous administration of oxygen was again started at the rate of 600 cc. per hour and at a pressure just sufficient to clear the glass viewing adapter proximal to the intravenous needle of the blood that had refluxed into it as the needle was inserted into his vein. At this rate and pressure it was continuously administered for the ensuing thirty hours, during which period the patient received 18,000 cc. of oxygen. His pulse rate was constantly maintained at 80 per minute, and the pulse was full and regular. The patient's respiratory rate was maintained at 20 per minute and was regular. His lungs were clear throughout. The heart sounds were of good quality. The blood pressure rose to 106 mm. of mercury systolic and 74 mm diastolic within two hours after the administration of oxygen was begun and remained at this level. The patient was mentally so alert that he realized that some unusual procedure was being attempted, from the number of observers who visited him during this period, and he commented on the fact. After thirty hours of intravenous injections of oxygen, cell volume by hematocrit reading was 37 per cent and specific gravity of the capillary blood 1.0549. On the day after the intravenous administration of oxygen was discontinued, one hypodermoclysis of 2,000 cc. of 5 per cent dextrose in isotonic solution of sodium chloride and one 500 cc. transfusion of whole blood were given. The patient was taking fluids by mouth on the third postoperative day and food on the fourth, and he left the hospital free of symptoms, on the twelfth day after operation.

CASE 2—C, a newborn boy, was delivered by podalic version on July 3, 1944. He sustained fractures of the right clavicle and both humeri and probable fractures of the skull and the spine during the delivery. The child was semicomatose and did not respond to any stimulation, and both lower and upper extremities were flaccid. No cry or sucking reflex was present. He was intensely cyanotic. Respiratory movements were shallow, of the abdominal type, extremely irregular and about 36 per minute. No breath sounds were heard, heart sounds were rapid and feeble. These conditions became progressively more pronounced for three days, despite transfusions (100 cc of Rh-negative compatible blood), cardiac stimulants and oxygen by nasal catheter. On the third day, the child appeared to be dying. There was pronounced edema of the thighs.

At this point, all supportive measures, including transfusions, were discontinued. Intravenous administration of 100 per cent oxygen was begun at the rate of 90 cc per hour and was continued without interruption for fourteen hours. Cyanosis completely disappeared within four minutes after the intravenous administration of oxygen was started. The respiratory rate dropped to 14 per minute within half an hour after the oxygen was started, its rhythm becoming regular. A strong cry and sucking reflex became manifest in eighty minutes, after the oxygen had been flowing for six hours, the lungs showed signs of expansion, and breath sounds were heard throughout the chest after eight hours of oxygen therapy. After twelve hours, the child having received 1,080 cc of oxygen intravenously, the edema of the thighs had totally disappeared. The child lived for three weeks after the oxygen was discontinued, without further therapy, taking its feedings well, breathing regularly and rhythmically and showing no further evidences of anoxemia or shock. During the third week, a complicating pneumococcal meningitis developed. Because of the paraplegia of the lower extremities and the severe injury to the cord, no attempt to treat the meningitis was made. At autopsy, fractures of the skull, the sixth cervical vertebra, the right clavicle and both humeri were found. There was a large organized subdural hemorrhage over the superior cerebral surfaces and numerous fading subpial ecchymoses. The cervical portion of the spinal cord was lacerated in the region of the vertebral fracture. There were gross (kernicterus and hepatosplenomegaly) and microscopic evidences of erythroblastosis. There were no residual changes suggesting that at any time during the life of the child had air embolism occurred. Numerous sections of the heart, the brain and the lungs failed to show any evidence of vascular rupture or perivascular hemorrhages such as have been described in cases of air embolism,¹³ and there was neither gross nor microscopic evidence of infraction in any organ.

CASE 3—B, a white male infant, was delivered on Jan 10, 1945 by midforceps at term, weighing 9 pounds 3 ounces (4,170 Gm). Resuscitation was difficult, requiring the use of a resuscitator for one hour and the injection of nikethamide and alpha lobeline into the cord. When breathing finally was begun, the respirations were irregular, extremely rapid (about 100 per minute) and shallow. The infant was extremely cyanosed. The extremities were toneless and limp. Tremors of the lips were noted. Heart sounds were of fair quality. No breath sounds could be heard on auscultation. The rectal temperature was 97 F. The child appeared to be in collapse. Intracranial hemorrhage was suspected.

13 Gonzales T H, Vance M and Helpert M. Legal Medicine and Toxicology, New York: D Appleton-Century Company Inc, 1937, pp 99 and 100. Weitzman C C and Cohen M. Rubin Test with Fatality, New York State J Med 37: 1582, 1937.

The infant was placed in an oxygen tent. Five-tenths cubic centimeter of a preparation of vitamin K was given intramuscularly. The trachea was aspirated and found patent. Hot water bags and blankets were applied to the body and extremities. After three hours of this regimen, the infant appeared to be dying.

The child was then taken from the oxygen tent and, with external heat still applied, intravenous administration of oxygen was begun at the rate of 200 cc per hour. The oxygen was continuously administered intravenously for the ensuing thirty-six hours, with three brief interruptions, of about twenty minutes each, necessitated by clotting within the needle. In all, the child received 7,000 cc of oxygen intravenously. Eight hours after the intravenous administration of oxygen had been begun, 100 cc of 5 per cent dextrose solution was given intravenously.

Cyanosis was lessened within a few minutes after the intravenous administration of oxygen was begun. In fifteen minutes, the child had become pink and remained so except during the periods when the oxygen was discontinued, relapsing rapidly into a state of deep cyanosis during these intervals. The respiratory rate slowly but progressively diminished, becoming 30 per minute and being regular and deeper in eight hours after the beginning of the intravenous injections of oxygen. The rectal temperature four hours after institution of intravenous injections of oxygen was 98 F. After eleven hours the rectal temperature was 99.2 F, after eighteen hours it was 100 F and remained at this level. The body of the infant had become warm by the time the intravenous injections of oxygen had been administered for ten hours. External heat was, however, continued for four hours longer, no external heat being supplied thereafter.

The infant began to manifest generalized convulsions six hours after delivery. These became more frequent and of longer duration. The child died on the third day after delivery. At autopsy, a large subdural hematoma and multiple subpial cortical ecchymoses were found. The left occipital bone showed a long transverse fissure fracture. The other organs showed severe congestion. The lungs showed a widespread patchy atelectasis. No evidence of intravascular or intracardiac gaseous contents was discernible. There was no evidence of cardiac tamponade nor any suggestion of embolization in any organ. Microscopic examination failed to show any signs of vascular laceration or of infarction in any organ.

SUMMARY AND CONCLUSIONS

Gaseous oxygen was administered intravenously to 12 dogs in which irreversible toxic shock had been produced experimentally and to 3 human beings with severe traumatic secondary shock. No symptoms of vapor lock (cardiac tamponade), gas embolization or other deleterious effect developed clinically, and no evidence of embolization or vapor lock was noted at autopsy in the animals.

Five of the 6 dogs treated with intravenous administration of oxygen completely recovered from the state of shock, their hemoconcentration falling from a level of 52 per cent to one of 70 per cent before treatment to preshock levels after treatment.

All 3 human beings recovered rapidly from the clinical and laboratory evidences of shock. The first clinical manifestations of improvement occurred in a matter of a few minutes after the intravenous administration of oxygen was begun. The earliest evidences of this improvement consisted in the return of normal color to mucous mem-

branes and an increasing bright pink-red color to the blood, followed by an elevation in blood pressure and diminution in respiratory rate. The concentration of blood cells and the specific gravity of the capillary blood, both previously extremely elevated (1 case), fell rapidly toward normal.

Gaseous oxygen, intravenously administered at pressures at or slightly above venous pressure and at rates of 60 to 600 cc per hour depending on the size and the age of the person, can be given with safety and may be of value in the treatment of secondary shock. So administered, it may be efficacious when oxygen by inhalation fails to yield therapeutic effects since by the intravenous route a lung functionally deficient because of the frequently present edema or other mechanism leading to faulty pulmonary aeration can be by-passed and the necessary oxygen made available to the body.

With the present status of available apparatus for administering gaseous oxygen intravenously, constant attention to the machine is imperative. Frequent regulation of the rate of flow and the pressure as the dynamics of circulation are altered under therapy are necessary. Experiments are presently under way to construct an apparatus that will automatically compensate for these and other variables and will eliminate the constant attention presently required.

STUDY OF GASTRIC LESIONS BY MEANS OF BIOPSY SPECIMENS REMOVED ENDOSCOPICALLY

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WHILE gastroscopy is one of the oldest methods of examination of the stomach, its limitations were so great that it was of little clinical help until the advent of the flexible gastroscope, with the pioneering work of Schindler. In the hands of one skilled in the use of such an instrument, gastroscopic examination now has become an important addition to the armamentarium of the gastroenterologist and of every one interested in gastric lesions.

In spite of its proved value, however, gastroscopy still possesses two definite defects. One is that a small but sometimes important area of the stomach cannot be visualized by the gastroscope, and the other is that diagnosis is almost completely established by topographic observation only. For many fairly well advanced lesions, such topographic observation is adequate to establish a diagnosis, as a matter of fact, in many such cases gastroscopic examination is hardly necessary for an understanding of the true nature of the disease. In the case of a small borderline lesion, visualization alone may be inadequate.

In the differentiation between early gastric cancer and benign ulcer, error in gastroscopic diagnosis is often encountered. To the surgeon, who has become more accustomed than the internist to the difficulty of differential diagnosis when confronted with such a small questionable lesion in the stomach at operation, this occasions no great surprise. He is familiar with many instances in which not only inspection leaves much to be desired but also palpation does not give the necessary information and a frozen section must be relied on. Because of the inability of gastroscopic observation alone to offer the greatest amount of help where it is needed, namely, in the early or the atypical case, the surgeon has probably taken to this method of examination somewhat less enthusiastically than have his colleagues in internal medicine.

It will be recalled that the cystoscope became much more valuable to the urologist when it became possible to remove a small portion

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of tissue from the bladder endoscopically for microscopic study. It will also be recalled that when a biopsy forceps was designed to be used with the bronchoscope the study of thoracic lesions and thoracic disease underwent an almost revolutionary change. By means of these instruments the removal of a small portion of tissue under direct visualization with subsequent microscopic study has changed the accuracy of diagnosis from one of opinion based on quick and incomplete observation to one of more careful study by use of the microscope. Because of the obvious value of such a method of study in examination of the stomach, one of us (B K) set about to construct such an instrument to be used in conjunction with the gastroscope. This was done with the help of the Phillips-Drucker Company, of St. Louis, and it has been recently described¹. The present report is a preliminary appraisal of the value of the study by biopsy of the stomach mucosa removed through the gastroscope by such a forceps.



Fig 1—Artist's drawing of view through gastroscope as the forceps removes a bit of tissue for biopsy. The case is one of atrophic gastritis.

A description of the instrument together with our technic of operation was presented in a previous publication. Briefly, the instrument is a flexible steel cable of fine caliber which can be attached externally to the gastroscope, thereby increasing by only 3 mm the diameter of the latter. The cutting head is abducted from the objective within the stomach and a small section of tissue excavated under visual control. This is regulated by manipulation of the proximal screw and lever apparatus adjacent to the gastroscopic ocular. After the tissue has been removed, the forceps head is rapidly adducted and the combined instruments are withdrawn (fig 1).

In no case so far has hemorrhage at the site of biopsy been alarming. Minor bleeding is always present. Indeed if this does not occur, it is

1 Kenamore, B. A Biopsy Forceps for the Flexible Gastroscope, *Am J Digest Dis* 7:539 (Dec) 1940.

felt that the biopsy specimen is of insufficient depth to be of diagnostic value. In many sections taken, strands of muscularis mucosae have been present.

In all, thirty-five biopsies have been obtained, and in no instance has any patient manifested untoward reactions. True, not in all cases in which biopsy has been attempted could tissue be removed, nor in every case could a particular area under suspicion be reached by the forceps. Such failures constitute a small percentage of the total number of attempts, however, and we think that they will detract but little from the ultimate value of the instrument.

Just as there are certain blind spots in ordinary gastroscopic examination, so are there in gastroscopic biopsy regions of the gastric mucosa which are inaccessible to the forceps. The most important of these is the antrum. The forceps head can be protruded as much as 1 cm. distal to the incisura angularis in any arc on the visual circumference of the field. The juxtapyloric portion of the antrum beyond, though readily seen, cannot be reached. Also, since the forceps is operated under visual control, the blind spots on the posterior wall and the greater curvature cannot be approximated. We have found that it is better to do preliminary routine gastroscopic study of the patient to confirm the clinical or the roentgenologic diagnosis before undertaking gastroscopic biopsy. Thus by doing two examinations the doctor is better orientated and the patient more cooperative.

The following abstracts of case records illustrate the adequacy of such stomach biopsies, taken with gastroscopic forceps. They also exemplify the high correlation in gastroscopic and pathologic diagnosis in our experience.

REPORT OF CASES

CASE 1—E. F., a white man of 65, was admitted to the Barnes Hospital in April 1940, with a history and physical signs suggestive of gastric cancer. Gastroscopic examination was reported as follows: "In depth I, the angulus and antrum were grossly deformed by a mutilating ulcerated, obviously malignant infiltrating lesion. In the center of this area, there was necrosis and minor bleeding. The pylorus was practically obliterated by the process, which extended up into the pars media (depth II) along the lesser curvature and posterior wall involving approximately the entire distal half of the stomach. In the proximal portion (depth III), there were patchy areas of atrophic mucosa."

At a second examination, with gastroscopic forceps a specimen for biopsy was taken from the lesser curvature just proximal to the angulus. On microscopic examination there was found a marked amount of inflammatory reaction in all of this tissue. "The most significant feature is the number of atypical malignant glandular structures which are inserted in a loose type of connective tissue. The nuclei are very large and take a deep stain, showing several mitotic figures. The glandular structures are fairly well differentiated for the most part. However there are a few cords of cells with typical malignant appearance around the

muscularis mucosae. The picture is typical of adenocarcinoma of the stomach" (fig 2)

CASE 2—C H, a white man of 63, was referred to the gastroscopic clinic of the Washington University School of Medicine from the Barnard Free Skin and Cancer Hospital, where a diagnosis of lymphosarcoma had been made and gastric involvement suspected. On gastroscopic examination at depth I, the antrum was noted to be red, thickened and smooth, suggesting an infiltrating lesion. The angularis was stiff, but at the pylorus there were rhythmic contractions. At depth II on the posterior wall in the greater curvature, the mucosa was noticeably thickened and irregular, with polypoid protrusions showing changes of color as seen in the antrum, although resembling an abnormal diffuse infiltrating process, it was not similar to ordinary carcinoma and was certainly distinguishable from hypertrophic gastritis. On the anterior wall and lesser curvature, changes typical of gastric mucosal atrophy were present.

The gastroscope, with forceps in place was then introduced and a biopsy specimen taken. Microscopic examination of this tissue showed absence of the gastric mucosa in many places. The stroma was densely infiltrated with a diffuse collection of lymphocytes in various stages of differentiation. While this appeared to be diffuse throughout, in one or two areas one could see a grouping together of these lymphocytes, with considerable variation in size and shape of the nuclei. From this study one can say that this was probably a collection of malignant lymphocytes, and the diagnosis of lymphosarcoma of the stomach was established (fig 3).

CASE 3—C C, a 68 year old man, was seen in the dispensary of the Washington University School of Medicine in April 1942, where a roentgenographic diagnosis of carcinoma of the stomach was made. The report of the preliminary gastroscopic examination was as follows: "At depth I the angulus appeared normal. The mucosa of the antrum was thickened, red and nodular, giving the appearance of hypertrophic gastritis. The pylorus showed rhythmic closure. At depth II similar though more pronounced changes were noted in the distal half. As the fundus was approached at depth III, these gradually faded to a nearly normal appearance. At a second operation, a biopsy specimen was taken with a gastroscopic forceps from the anterior wall of the pars media. On microscopic examination the sections showed mucosa which was characterized by great thickening. The glands were hyperplastic, with occasional dilatations, and in some areas where the glands were cut longitudinally there was tortuosity. The cells of the glands were regular but showed numerous mitotic figures. In the stroma between the hyperplastic glands, a rather dense round cell infiltration with some fibroplasia was seen. A diagnosis of chronic hypertrophic gastritis was made" (fig 4).

CASE 4—I W, a Negro woman of 34 years, was seen in the dispensary of Washington University School of Medicine in March 1941. Physical examination and gastrointestinal roentgenographic examination revealed no organic disease. Gastric analysis showed no free hydrochloric acid. Gastroscopic study was reported as follows: "At depth I the angulus, antrum and pylorus appeared normal. At depth II there were numerous patchy areas of mucosa showing thinning, with a grayish green color change and a visible vascular pattern of atrophic gastritis."

At a second examination a biopsy specimen was taken with the gastroscopic forceps from a characteristic area of the lesser curvature of the pars media. Microscopic examination showed the mucosa to present short, narrow crypts leaving the glands which have their constituent cells and cell margins partly distorted and obliterated by chronic inflammatory reaction consisting of lymphocytic and plasma



Fig 2—Malignant transformation of gastric mucosa showing characteristic picture of adenocarcinoma $\times 400$



Fig 3—Destruction of normal mucosal architecture by diffuse infiltration with malignant lymphocytes. The picture is one of lymphosarcoma $\times 400$



Fig 4—The mucosa is edematous and infiltrated with inflammatory cells. The picture is one of hypertrophic gastritis $\times 400$



Fig 5—Mucosal atrophy is well illustrated. Note the blood vessel extending into the thinned submucosa. There are edema and infiltration by lymphocytes and plasma cells. The picture is one of atrophic gastritis. $\times 400$

cell infiltrations with a few polymorphonuclear leukocytes and moderate edema of the underlying stroma. The mucosal surface itself was covered by necrotic exudate and debris containing a few dead cells. The submucosa was largely replaced by collagenous fibrous tissue. There was noted considerable increase in vascularity of the submucosa. A diagnosis of chronic atrophic gastritis was made (fig 5).

COMMENT

From the cases described, it would seem to us apparent that this means of examination has much to offer both the internist and the surgeon. It can be of definite value as a positive method of differentiating between benign and malignant gastric lesions. What may be more important, it provides a method of studying gastric mucosa before autolytic change can make its appearance in various types of disease and a method for studying the progressive changes occur that one might anticipate following certain therapeutic procedures.

SUMMARY AND CONCLUSIONS

Data accumulated in the use of the gastroscopic biopsy forceps for the microscopic study of gastric mucosa are presented. In trained hands the instrument is safe and offers a method of more exact study of gastric diseases. Abstracts of case records illustrate the diagnostic aid offered by this method.

DIVERTICULA OF THE STOMACH

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A DIVERTICULUM of the stomach is not a frequently encountered lesion, as is evidenced by the paucity of case reports, which now number some 150 cases. The table is offered to summarize the larger series reported, with the source of the material indicated when

*Cases of Diverticula of the Stomach Previously Reported **

Author	Year	Number of Cases of Diverticula	Source of Cases			
			Autopsy	Operation	Barium Studies	Gastroscopic Examination
Larimore and Graham Surg, Gynec & Obst 45 257, 1927	1927	1			3,440	
Sinclair ⁸	1929	1				
Bell and Gordon J A M A. 94 534 (Feb 22) 1930	1930	4				
Rivers et al ⁷	1935	4 25	3,662			
Martin ¹	1936	5				
Nathanson and Steiner ^{1b}	1936	1				
Rigler and Eriksen Radi ology 20 6 1936	1936	2			4,236	
Wigby ⁹	1937	2				
Shifflett ¹¹	1937	43			786	
Cheney and Newell ¹²	1937	2			11,828	
Schindler ²²	1939	3				1,000
Reineke J Med 22 1a2, 1941	1941	7				
Reich ³	1941	8			19,022	
Schmidt and Walters	1941	10		11,234		
Love ^{1a}	1942	1				
Balfour ⁶	1942	9	2,565†			
Malissa ⁵	1943	2			22,400	

* This table lists most of the reported cases of diverticulum of the stomach with the sources of the material in instances in which the source is mentioned

† Gastric tumors

significant. The somewhat dubious nature of many of the cases listed is suggested by the preponderance of those detected by gastrointestinal roentgenograms after a meal of barium sulfate, an examination which cannot be expected to differentiate the true diverticula from the pseudo-diverticula in all instances.

According to Martin,¹ this condition was first described by Moebius in 1661 and by Fournier in 1774.

From the surgical service Gallinger Municipal Hospital

1 Martin, L. Diverticula of the Stomach, Ann Int Med 10 447, 1936

The anatomic sites of these diverticula have varied widely in the series reported. Schmidt and Walters² stated that most of them are found in the cardiac area on the posterior wall near the lesser curvature. Reich³ reported 8 cases, in which all the diverticula occurred on the cardia, arising from the lesser curvature, and he attributed this distribution to a local predisposition due to splitting of the longitudinal muscle layer in this area into the muscular fasciculi, thus leaving only the circular muscle to cover the mucosa. Eusterman and Balfour⁴ located 43 per cent of the anomalies in the fundus, 43 per cent in the prepyloric area and 14 per cent in the midportion of the stomach. Martin,¹ reviewing 103 cases, found sixty-three diverticula in the cardia, eleven in the midportion of the lesser curvature, fourteen in the prepyloric region of the lesser curvature, five in the midportion of the greater curvature, four in the prepyloric area of the greater curvature and six in miscellaneous sites. Maissa⁵ localized most of them in the posterior wall of the cardiac portion and said that they are rare in the prepyloric region and greater curvature. In striking contrast, however, with these reports, Balfour⁶ stated that the majority are found near the pylorus.

Analysis of the literature fails to reveal any particular predilection for either sex.

The age at onset of symptoms due to these growths is usually from 30 to 50 years. Rivers, Stevens and Kirklin,⁷ reviewing 14 cases, found the youngest patient to be 26 years old. The ages of the 8 patients reported by Reich³ ranged from 36 to 71 years. Much younger patients have been reported, however, in isolated protocols, such as the discovery of pathologic diverticula in an embryo by Broman and Pernkoff, in a 4 month old infant by Sinclair,⁸ in a 7 year old child by Wigby⁹ and in another child of the same age by Gile.¹⁰

2 Schmidt, H. W., and Walters, W. Diverticula of the Stomach, *Am J Surg* **52** 315, 1941.

3 Reich, N. E. Gastric Diverticula, *Am J Digest Dis* **8** 70, 1941.

4 Eusterman, G. B., and Balfour, D. C. The Stomach and Duodenum, Philadelphia, W. B. Saunders Company, 1935.

5 Maissa, P. A. Gastroduodenal Diverticulosis, *Prensa med argent* **30** 2014, 1943.

6 Balfour, D. C., in Christopher, F. Textbook of Surgery, ed 3, Philadelphia, W. B. Saunders Company, 1942.

7 Rivers, A. B., Stevens, G. A., and Kirklin, B. R. Diverticula of the Stomach, *Surg, Gynec & Obst.* **60** 106, 1935.

8 Sinclair, N. Congenital Diverticulum of the Stomach in an Infant, *Brit J Surg* **17** 182, 1929.

9 Wigby, P. E. Diverticulosis. Two Cases, *Texas State J Med* **33** 43, 1937.

10 Gile, J. F. Diverticula of the Stomach, *New England J Med* **204** 268, 1931.

These growths have been classified by Schmidt and Walters² as 1 True (congenital) diverticula, in which all layers of the stomach are intact, they are due to malformation or interrupted development during the fetal period 2 False (acquired) diverticula The latter are of two types (a) Pulsion type, e g, those secondary to labor, pyloric obstruction, vomiting, coughing, constipation or foreign bodies The authors feel that these are due to increased intraluminal pressure These may also be caused by eroding lesions, such as gastric ulcers or carcinomas (b) Traction type, e g, those resulting from perigastric adhesions due to inflammatory lesions of the spleen, gallbladder and pancreas

Shifflett¹¹ agreed with this concept in its essential details Gile¹⁰ said that the true type with all its coats intact is congenital, whereas the false types are mucosal hernias through the muscular walls The views of Reich,⁸ who considered these diverticula analogous to those of the esophagus, have been presented in the discussion of anatomic sites (see the following paragraphs)

These diverticula are usually pear shaped, with relatively small orifices, although wide-necked sacs are not unusual Obviously, as with all diverticula, those with narrow necks have the greater potentiality for disease In the series reported by Eusterman and Balfour,⁴ the sacs had an average length of 7.5 cm and a neck of 1 cm in diameter Rivers, Stevens and Kirklin⁷ found that the masses varied from 1 mm to 5 cm in diameter The mucosa of the stomach is continued into the diverticulum without interruption

It is noteworthy that the majority are asymptomatic, the occurrence of this type being estimated by Rivers, Stevens and Kirklin⁷ as 64 per cent

Reich⁸ asserted that there is associated gastroduodenal disease in 30 per cent of cases Such accompanying lesions as have been reported are (1) benign tumors in the sac (adenomas and myomas are described by Schmidt and Walters²), (2) malignant tumors in the mass, reported by C. H. Mayo,¹² Cheney and Newell¹³ and Mellon¹⁴, (3) syphilitic ulceration as described by Joltrain¹⁵), (4) hiatus hernia, (5) hetero-

11 Shifflett, E. L. Diverticula of the Stomach, *Am J Roentgenol* **38** 280, 1937

12 Mayo, C. H. Diverticula of the Gastro-Intestinal Tract Their Surgical Significance, *J A M A* **59** 260 (July 27) 1912

13 Cheney, G., and Newell, R. R. Large Diverticula of the Gastric Cardia, *Am J Digest Dis* **3** 920, 1937

14 Mellon, R. R., and others. The Incidence of Carcinoma in Gastro-Intestinal Diverticulosis, *Surg Gynec & Obst* **33** 177, 1921

15 Joltrain, E. Syphilitic Origin of Ulcer with Diverticulum, *Bull Soc franç de dermat et syph* **43** 1643, 1936

topic tissue in the diverticulum (Martin¹ has collected 15 cases of pancreatic inclusions), (6) recurrent and massive bleeding, such as given in case reports by Love,¹⁶ Brown and Priestly¹⁷ and Schmidt and Walters², (7) duodenal ulcer, as in the case of Nathanson and Steiner¹⁸, (8) multiple diverticula, associated with diverticulosis of the colon and duodenum, occurring in 12 per cent of cases according to Eusterman and Balfour⁴, (9) diverticulitis, reported as not occurring by Reich,³ but considered frequent by Maissa⁵ and (10) perforation and bleeding into the peritoneal cavity (this complication occurred in the case reported in this paper)

The symptomatology of this condition has no features characteristic or even suggestive of the underlying pathologic condition. Its rarity will prevent acute mental awareness of the disease. At Mayo Clinic there was a preponderance of gastric malignant growths over this entity in a proportion of 266 to 1. The lesions which simulate it most closely are far commoner and occur in the same age groups. Such symptoms as are described in the literature in individual cases would not serve to differentiate it from any of a dozen other gastroduodenal afflictions. In general, the diagnosis will be ascertained only by roentgenologic examination, gastroscopic examination, operation or necropsy.

Reference to the table will reveal that the greater number of gastric diverticula have been revealed by roentgenologic investigations. The first such diagnosis was reported by Brown¹⁹ in 1916. It must be realized, however, that certain precautions in interpretation of observations must be taken if large numbers of false positive diagnoses and errors of failure to demonstrate the lesion are to be avoided.

Akerlund²⁰ first listed the criteria for the diagnosis by serial gastro-intestinal roentgenograms: (1) a mobile sac unattached to extra-gastric tissues, (2) a well defined, smooth and regular shadow, noted from various angles, (3) generally, no tenderness over the area of filling.

To these, Sandstrom²¹ has added this criterion: (4) the presence of a nichelike opaque spot surrounded by a defect in the contrast shadow the appearance of which resembles an ulceration without surrounding infiltration. This is best seen in a vertical position and during expiration.

16 Love, M. Gastric Diverticula, *Brit J Surg* **30** 180 1942

17 Brown, P. W., and Priestly, J. T. Massive and Recurrent Hemorrhage from Diverticulum, *Proc Staff Meet Mayo Clin.* **13** 270 1938

18 Nathanson, L., and Steiner, M. Diverticula at Cardiac End with Report of Case, *Radiology* **26** 326, 1936

19 Brown, G. E. An Unusual Stomach Case with Roentgenographic Findings, *J A M A* **66** 1918 (June 17) 1916

20 Akerlund, A. Diverticula of the Stomach from a Roentgenological Viewpoint, *Acta radiol* **2** 476, 1923

21 Sandstrom, C. Contribution to the Roentgenological Appearance in Cases of Benign Diverticular Growths of the Stomach, *Acta radiol* **10** 427, 1929

Reich³ has contributed these suggestions (5) the demonstration of rugae in the mucosal lining of the neck by careful technic, (6) the location of the shadow, occurring most commonly at the cardia and the lesser curvature toward the posterior wall, (7) the retention of barium at the site of the shadow on a six hour plate, (8) the mucosal pattern of the stomach itself, soft, well defined and regular and showing no evidence of irritation (well defined rugae may lead right up to the diverticulum), and (9) occasional ability to empty the sac by changing the position of the patient

Roentgenologically, the differential diagnosis between a penetrating ulcer and a diverticulum is based on the following points In ulcer there is a tendency toward spasm near and opposite to the lesion and infiltration or rigidity of the mucosal border, features absent in the simple diverticulum In addition, the gastric analysis and characteristic food-pain relationship may be helpful

In differentiating the diverticulum from a diaphragmatic hernia, the following features may be helpful The diverticulum is larger during expiration, the reverse is true in hernia A shadow in the chest is present in hernia In hernia the shadow may be constricted where it passes through the diaphragm

Gastroscopic examination may be of aid in the diagnosis Schindler²² discovered three diverticula during 1,000 gastroscopic examinations Schmidt and Walters² said that gastroscopic examination will reveal a circular hole with a sharply defined margin and no sign of infiltration The mucous membrane of the stomach surrounding the opening will usually be of normal appearance

The treatment of choice in the cases in which symptoms are presented would seem to be surgical, as medical therapy could hardly be expected to eliminate the anomaly The fear of carcinomatous degeneration is sufficient alone to recommend this manner of management

We have recently had the opportunity to treat a patient with a gastric diverticulum which was involved in a complication not previously reported in the literature

REPORT OF A CASE

A 33 year old Negro woman was first admitted to the hospital on March 7, 1945, with complaints of pains in the lower part of the abdomen for six weeks and vomiting for one week Her pain had been gradual in its onset, becoming progressively severer, more cramping and more intermittent, with no tendency to radiate She had noted urinary urgency and frequency for three months but no pain in the back There was no history of indigestion, melena change in stool habits or hematemesis In 1939 she had an operation for pyosalpinx, but her menstrual periods had been regular, asymptomatic and of usual duration with no intermenstrual bleeding Her last period was ten days prior to admission

²² Schindler, R Incidence of Various Types of Gastric Disease as Revealed by Gastroscopic Study, *Am J M Sc* **38** 280, 1939

On admission her blood pressure was 110 systolic and 70 diastolic, her pulse rate 112 per minute and her respiratory rate 32 per minute. The rectal temperature was 100.6 F. The significant signs in the physical examination were limited to the abdomen and the pelvis. Her abdomen was not distended but was acutely tender in all areas, especially in the lower portions. There was a moderate amount of muscular splinting throughout. Peristalsis was felt by all examiners to be depressed. Examination of the pelvis revealed what was considered to be a boggy mass in the cul-de-sac, which was extremely tender. The laboratory tests showed a hemoglobin content (Sahli) of 50 per cent and a white blood cell count of 7,000. In view of these findings, an exploratory laparotomy was performed. The preoperative diagnosis was considered to be ectopic pregnancy.

Exploration was performed through a lower right rectus incision. When the peritoneal cavity was opened, about 1,500 cc of blood was encountered. The pelvis showed no evidence of ectopic pregnancy. Further exploration revealed that the bleeding was originating from a rent in the gastrohepatic ligament but that no active hemorrhage was occurring at the moment. Owing to deterioration of the condition of the patient despite the parenteral administration of plasma and blood, the operation was concluded. The diagnosis seemed vague, but rupture of a gastrohepatic cyst was proposed as the probable diagnosis. The postoperative course was complicated by a bout of pyelonephritis. The patient was discharged on April 9, 1945, asymptomatic at the time.

On April 25 she was again admitted, with generalized abdominal pain of three days' duration, unassociated with nausea or vomiting. However, she stated that she had noted three tarry stools since her discharge. The abdomen was moderately tender in the epigastric region, but there was no indication of peritoneal irritation. The blood pressure was 135 systolic and 80 diastolic, the pulse rate 92 per minute, the respiratory rate 22 per minute and the rectal temperature 100.6 F. Laboratory examinations showed hemoglobin content (Sahli) 56 per cent, red blood cell count 2,700,000 and white blood cell count 7,100. The urine contained many pus cells, occasional casts and albumin (2 plus), and there was a maximal specific gravity of 1.015 on the Fishberg concentration test. Stools contained blood on repeated tests. The total serum protein level was 6.2 Gm per hundred cubic centimeters, bleeding, clotting and prothrombin times were normal. The result of a tourniquet test was normal. Gastric analysis showed free blood and normal free and total hydrochloric acid. Serial roentgenograms of the gastrointestinal tract revealed no lesion of the stomach or duodenum. The Kahn reaction was negative. With the conditions previously observed at operation in mind, the clinical picture seemed compatible with a diverticulum.

On May 7, with the patient under tetracaine hydrochloride spinal anesthesia, an exploratory operation was again performed through an upper midline incision. The entire upper part of the abdomen was occupied by extremely dense adhesions which had sealed all the organs in the area into a single mass. After lysis of these adhesions, the spleen was found to be extremely enlarged, obscuring almost the entire greater curvature of the stomach. The gastrohepatic ligament was greatly thickened and indurated. A perforation of a gastric ulcer into the spleen was now considered, and the stomach was opened in search of such a lesion. The entire mucous membrane lining the stomach was found to be normal in feel and appearance. In order to expose the posterior aspect of the stomach, it was necessary to remove the massive spleen. After the splenectomy, a bulbous mass was exposed behind the stomach, in the lesser omental sac, which was sealed off completely by the surrounding inflammatory reaction. This mass proved to

be the lower pole of the diverticulum and was dissected up to its junction with the posterior wall of the stomach in the cardiac region. It arose just posterior to the lesser curvature. Its base was excised and the hole in the stomach closed with a double row of inverting sutures. Now a very narrow neck could be demonstrated emptying into the lumen of the stomach through an extremely fine orifice. The mucosa of the stomach proper surrounding the orifice was normal in appearance and was continuous with the mucosal lining of the sac. The sac itself measured 11 cm in length, with a maximal diameter of 3 cm. Microscopic examination of the diverticulum showed that its mucosal lining was extremely hemorrhagic and necrotic and that its muscular wall was fibrotic and infiltrated with hemosiderin deposits. The spleen showed only a generalized chronic inflammatory reaction.

COMMENT

The diagnosis in this case was not made either during or after the first operation until the additional symptom of melena was experienced. The combination of a known inflammatory mass in the gastrohepatic ligament with hemoperitoneum and a later episode of gastric bleeding, without evidence of gastric or duodenal ulcer, cirrhosis of the liver or bleeding diathesis, led my colleagues and me to suspect the presence of a gastric diverticulum, despite its rarity. Such fortuitous circumstances as these are exceptional. The operation appears to have relieved the discomfort of the patient.

SUMMARY

Diverticulosis of the stomach is an uncommon condition, as is evidenced by the fact that only about 150 cases have been reported. The most frequent site of occurrence is on the posterior wall near the lesser curvature in the cardiac region. In approximately 30 per cent of the cases there have been other associated gastroduodenal disease, which is more likely to cause symptoms than the diverticulum itself. About one in every three diverticula will be the site of adverse symptoms. The condition has no characteristic or even suggestive symptoms that would tend to differentiate it from other, far more common, lesions of the upper gastrointestinal tract. The eventual diagnosis will usually be made only on the observations at necropsy or at operation or by the results of several roentgenologic studies of the gastrointestinal tract or gastroscopic examination. It is easily missed by any of these methods.

A case is presented which illustrates rupture and bleeding into the peritoneal cavity due to a gastric diverticulum which was diagnosed clinically by an uncommonly fortunate series of events. This complication of diverticulum of the stomach has not been previously reported.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1944

A Review Prepared by an Editorial Board of the American Academy of
Orthopaedic Surgeons

XIII Fractures

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IN 1944, the most significant articles on fractures were concerned with the use of penicillin in compound wounds. Interest in external fixation devices was apparently waning as more of the limitations were becoming apparent. As in the past two years, the largest number of articles on fractures were those from men in military service, in which war experiences were recounted. Fortunately, this will be the last year that war surgery will play so prominent a part in current medical literature.

Fractures of the Upper Extremity—Of all the articles examined on this subject, more than half described a common military injury in the upper extremity—fracture of the carpal scaphoid bones.

Greenlee³⁷⁷ discusses posterior dislocation of the sternal end of the clavicle. Symptoms of encroachment on the trachea and the esophagus, as were present in the case reported, are of more importance than the dislocation itself. In the author's case, open reduction was done. No internal fixation was employed, but immobilization in a shoulder spica cast for five weeks was employed. The patient made a complete recovery. The diagnosis and treatment are discussed, the point being brought out that most surgeons prefer open reduction but a few advocate resection of the sternal end of the bone. A review of the literature emphasizing the paucity of articles on the subject is included.

Lee³⁷⁸ describes an oblique fracture through the upper epiphyseal plate of the humerus in which a spicule of the shaft is split off with the humeral head. The broad edge of the distal fragment protrudes through a small tear in the capsular extension of the shoulder joint, with the long head of the biceps tendon lying under the anterior edge of this fragment. Manipulation will not reduce these fractures, and operation is always indicated. The fracture site is approached through an anterolateral incision, care being taken not to damage the axillary nerve. The frac-

377 Greenlee, D. P. Posterior Dislocation of the Sternal End of the Clavicle, J. A. M. A. **125** 426-428 (June 10) 1944

378 Lee, H. G. Operative Reduction of Unusual Fracture of Upper Epiphyseal Plate of Humerus, J. Bone & Joint Surg. **26** 401-404 (April) 1944

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ture is reduced, and fixation is done with a long vitallium screw After closure of the incision, a shoulder spica cast is applied for six weeks Three cases are reported Treatment of the 3 patients brought excellent results [ED NOTE (L D B) —Open reduction of epiphysal fractures of the upper end of the humerus are thought to be unnecessary by many of the writers on this subject]

Gershman's ³⁷⁹ survey of orthopedic surgeons on requirements for an adequate first aid humerus splint for compound fractures reveals the importance of (1) speed of application, (2) comfort of the patient, (3) adequacy of the immobilization, (4) availability of mechanical appliances, (5) multiplicity of wounds, especially of the thoracic wall, and (6) difficulty of applying a cast to/an anesthetized patient The Jergesen "elephant trunk" splint seems to meet these requirements It consists of anterior and posterior plaster splints from the fingers, up the forearm and arm and diagonally across the front and back of the chest The shoulder is fixed in a position of 10 to 15 degrees of abduction, with 20 degrees of forward flexion, the elbow at right angles and the wrist dorsiflexed [ED NOTE—This is, in effect, a light shoulder spica cast, which is well suited to emergency treatment of fractures of the humerus It is not, of course, adequate for final fixation The hanging cast is the ideal method for treating most fractures of the humerus, but it is of questionable value in cases in which transport is a major problem or in which wounds must be frequently examined]

Loomis ³⁸⁰ calls attention to the fact that myositis ossificans more commonly affects the brachialis muscle than any other muscle of the body It is also commoner following posterior dislocation of the elbow The fibers of the brachialis muscle crossing the front of the elbow joint are torn and bruised after a posterior dislocation This leads to loss of blood supply, with intramuscular hematoma and degeneration in the torn and bruised muscle fibers Periosteal stripping of the capsule about the joint furnishes calcium In the presence of these two factors pre-ossseous substance may be formed He believes that the usual method of reduction of the dislocation, consisting in extension and hyperextension of the elbow followed by traction and flexion, aggravates the damage to the muscle by further stretching and tearing the muscle fibers, thereby increasing the chances for myositis ossificans to develop

The author advocates reduction with the elbow flexed to 90 degrees and the forearm in midposition Strong traction is applied to the forearm with countertraction on the humerus After traction the elbow is

³⁷⁹ Gershman, M A Simple Method of Immobilizing Compound Fractures of the Humerus, *M Bull North African Theat. Op* (no 1) **2** 12-14 (July) 1944

³⁸⁰ Loomis, L K Reduction and After-Treatment of Posterior Dislocation, with Special Attention to Brachialis Muscle and Myositis Ossificans, *Am J Surg* **63** 56-60 (Jan) 1944

flexed beyond 90 degrees to avoid fracture of the coracoid process, and strong pressure is applied to the anterior aspect of the lower part of the humerus, which effects the reduction. After reduction, a posterior plaster splint is applied with the elbow still flexed and the forearm in midposition. When the swelling has subsided, a light unpadded plaster cast is applied, extending from the axilla to the palm. The patient is encouraged to perform his usual work if possible. After three or four weeks, the cast is removed and a roentgenogram taken. If calcification is seen in the brachialis muscle, the cast is continued until the mass disappears.

In a group of 713 cases of fracture of the elbow in children below the age of 12 reported by Boyd and Altenberg,³⁸¹ there was this distribution of fracture types

Types of Fractures	Approximate Percentage
Supracondylar fractures	65
Condylar fractures	25
Fractures of the neck of the radius	5
Monteggia fractures	2
Olecranon fractures	2
T-condylar fractures	1

In supracondylar fractures, the damage to nerves at the elbow or the circulatory disturbances are often more serious than the fracture. Uncomplicated supracondylar fractures are reduced by traction and direct pressure over the fragments. Fixation in acute flexion anchors them. Some irreducible fractures require operation to replace the fragments, followed by fixation with steel nails. Fractures of the external condyle of the humerus usually require open reduction to replace them and anchor them with a vitallium screw. Exact reposition is essential to normal growth of the elbow, and muscle pull makes it impossible to sustain the reduction without some type of internal fixation. Fractures of the medial epicondyle of the humerus generally require open reduction, exact replacement and fixation with a nail or screw.

Fractures of the neck of the radius in children should be treated conservatively by direct manipulation. It is undesirable to remove the radial head in children. Monteggia fractures (fracture of the shaft of the ulna with dislocation of the head) in children can usually be reduced satisfactorily without operation and secured by cast fixation. [ED NOTE—This is an excellent review of the fracture problems which are common in young patients and which are potentially the most disabling injuries in children.]

³⁸¹ Boyd, H. B., and Altenberg, A. R. Fractures About the Elbow in Children, *Arch Surg* 49:213-224 (Oct.) 1944.

Dickson³⁸² points out that fractures in the middle third of both bones of the forearm are often difficult to maintain in proper position. The author has devised an ingenious and relatively simple method of securing the bones, by passing a Kirschner wire longitudinally through the medullary canal and across the fracture line. A slanting hole is made (in the lower end of the radius and in the upper end of the ulna), and the wire is pushed into the medullary space with pliers until it crosses the fracture line. If necessary, an incision is made over the fracture to secure proper apposition of the fragments. When the wire has passed the fracture line, the end is cut off and bent into a hook to facilitate its later removal. [ED NOTE—In a personal communication, the author stated that this operation is easier if the blunt end of the wire is inserted in the medullary canal and if the hook is bent in the wire before it is inserted. This appears to be a most useful method of anchoring these potentially troublesome fractures.]

Deterling³⁸³ analyzes his series of 22 cases of Colles' fracture, covering a ten month period. He emphasizes the necessity for complete reduction, done with the patient under general anesthesia. A solid plaster cast extending to the elbow is employed for fixation. The hand is in palmar flexion and ulnar deviation. The fracture is kept immobilized until there is sufficient union as revealed by roentgenologic examination. This requires six to thirteen weeks. After removal of the cast, physical and occupational therapy is used.

Comminuted Colles fractures are treated with skeletal traction by means of a Kirschner wire through the first metacarpal bone or the proximal phalanx. A careful follow-up is of the utmost importance. Excellent results are reported.

Rogers³⁸⁴ presents a review of 328 fractures of the lower end of the radius seen in St. Mary's Hospital, Paddington, England, in 1942 and 1943. There were 59 simple Colles fractures, 108 fractures with oblique posteromedial fragments involving both the radiocarpal and the radioulnar joints, 39 comminuted Colles fractures and 11 fractures with vertical fracture of the radial styloid process. [ED NOTE—The main point of this article is that "no two Colles' fractures are alike" and that roentgenograms should be carefully studied before treatment is begun, to make certain that the surgeon understands the problem before him.]

382 Dickson, J. A. Intramedullary Fixation of Certain Fractures of Both Bones of the Forearm, *Cleveland Clin Quart* **11** 62-66 (July) 1944.

383 Deterling, R. A. Jr. Treatment of Colles Fracture, *Pennsylvania M J* **47** 583-586 (March) 1944.

384 Rogers, S. C. An Analysis of Colles Fracture, *Brit M J* **1** 807-809 (June 17) 1944.

Anderson and O'Neil³⁸⁵ discuss the disability produced by the shortened and malunited lower end of the radius in comminuted Colles fractures. Attention is called to the difficulty in maintaining complete reduction due to the crushing of the cancellous bone of the lower end of the radius and the pull of the strong radial muscles. A method of skeletal traction in connection with skeletal halfpin countertraction and immobilization by means of two slender steel rods clamped to the traction pins, instead of a cast is described. The traction wire is a 0060 Kirschner wire passed perpendicularly through the distal third of the shaft of the second metacarpal bone or through the center of the first metacarpal bone. The wire is clamped to a U-shaped holder. Countertraction is obtained by placing two half-pins of 0080 wire at an angle into the lateral aspect of the radius above the fracture. These are joined by two steel rods. The fracture is reduced with the patient under anesthesia and the apparatus adjusted to maintain reduction. The method is also applicable for arthrodesis and malunited fractures of the wrist. The period of immobilization and traction is much longer than that usually employed. Traction for ten to twelve weeks is recommended.

The article is well illustrated and the diagram clear and concise [ED NOTE (L D B) —Most Colles fractures can be adequately treated by simple plaster fixation.]

Morton³⁸⁶ states that fractures of the wrist and the hand are commoner in military surgery than in civil practice. Fractures of the scaphoid bone are relatively frequent and require long immobilization. For nonunion of this fracture, the Murray bone graft operation is much preferable to excision of the fragments. The author obtained solid bony union in 9 cases of bone grafts.

Fractures of metacarpal bones are common and are best reduced by direct traction or by use of the author's padded clamp. Immobilization is often secured by passing wires through the fractured bone into the adjacent intact metacarpal bone. The author also uses an external bar to anchor the protruding portion of the wires.

In fractures of the phalanges, longitudinal intramedullary wires are effective in securing fragments in proper position.

The author reports in detail 32 cases of fracture of the scaphoid bone. [ED NOTE (L D B) —In considering the use of wires and other devices for these fractures, it should be kept in mind that infection in the hand is a horrible complication.]

385 Anderson, R, and O'Neil, G. Comminuted Fractures of Distal End of the Radius, Surg, Gynec & Obst **78** 434-440 (April) 1944

386 Morton, H S. Fractures of the Wrist and Hand, Canad M A J **51** 430-434 (Nov) 1944

Bonnin and Greening³⁸⁷ present a complete and detailed study of injury to the triquetrum. Two forms of indirect injury are discussed (1) injuries by compression and (2) ligament traction (sprain) fractures.

Diagnosis of the injury by means of roentgenograms and physical signs is discussed. For the ligament traction fractures, immobilization in plaster for three weeks usually results in a complete clinical cure, although the fracture may not appear united in the roentgenogram. Compression fractures of the triquetrum of any severity require a longer period in plaster.

McKim³⁸⁸ observed more than 125 fractures of the carpal scaphoid bone in two years in a Canadian army camp. They were treated by cast fixation for eight to ten weeks. Treatment was continued until there was roentgenologic evidence of solid bony union. All the fractures in this series obtained complete healing.

Dickson and Shannon³⁸⁹ report on a series of 257 fractures of the carpal scaphoid bone seen in three years in the Canadian army overseas. The fractures which were not treated early showed the poorest results. All the fractures treated early gained adequate union. The worst error in these cases was failure of diagnosis at the time of the accident. In the cases of nonunion, bone graft is useful in obtaining union, but long postoperative fixation is essential. [ED NOTE—This article has much valuable detailed information about the various types of fractures. Interested persons would do well to go to the original article for the fine points of this problem.]

In two and a half years at a royal naval hospital, Robertson and Wilkins³⁹⁰ treated 100 patients with fracture of the carpal scaphoid bone. The injury almost always followed a fall on the outstretched hand. A significant diagnostic sign was pain on percussion of the tip of the outstretched thumb. Four roentgenographic views were taken of suspected fractures to insure proper diagnosis. All patients were treated with nonpadded casts from the upper forearm to the metacarpal heads. The thumb was moderately extended, and this was found to be satisfactory without the extreme extension devised by Buxton. The average period of immobilization was twenty-six weeks. [ED NOTE (L D B)—The described multiview roentgenograms should be routine in the examination of all injuries about the wrist.]

387 Bonnin, J. G., and Greening, W. P. Fractures of Triquetrum, *Brit J Surg* **31** 278-283 (Jan) 1944.

388 McKim, L. H. Fractures of the Carpal Scaphoid. *Bull Am Coll Surgeons* **29** 142 (June) 1944.

389 Dickson, J. C. and Shannon, J. G. Fractures of the Carpal Scaphoid in the Canadian Army, *Surg, Gynec & Obst* **79** 225-239 (Sept) 1944.

390 Robertson, J. M. and Wilkins, R. D. Fracture of the Carpal Scaphoid, *Brit M J* **1** 685-687 (May 20) 1944.

Obletz³⁹¹ reports on 45 cases of fracture of the carpal scaphoid bone in young vigorous men in an army training camp during an eighteen month period. The lesion is rarely seen in older persons or in women of any age. A study of the blood supply to the carpal scaphoid bone revealed that every specimen examined had at least a few arterial foramina throughout the length of the bone. There was evidence of adequate blood supply to both the proximal and the distal portion in about 67 per cent of the bones examined. Fracture through the mid-portion of the bone could interrupt the blood supply to the proximal fragments in between 13 and 33 per cent of the cases. The fracture is produced by a fall on the outstretched hand but the wrist is not hyperextended. A hairline fracture is produced usually through the mid-portion, without displacement of the fragments. Hyperextension of the wrist may result in separation of the fragments.

The fractures are divided into two types: type 1, fractures without interruption of the blood supply to either fragment; and type 2, fractures with interruption of the blood supply to the proximal fragment. Most of the fractures (37 cases) are type 1. In these cases roentgenograms made three to four weeks following injury reveal the fracture line more distinct than at first, but there is diffuse homogeneous decalcification of both fragments of the scaphoid bone indicating normal blood supply. In six to eight weeks the fracture line is partially or completely obliterated and the decalcification process has stopped. There may be evidence of some recalcification. After the fracture unites and the cast is removed, the carpal bones resume their normal density.

There were eight fractures of type 2. These showed interruption of blood supply to the proximal fragment as evidenced by the normal density of the proximal fragment in the presence of generalized decalcification in all the bones. In these cases union occurs but much more slowly. This period of temporary avascularity is not to be confused with aseptic necrosis, because with proper protection and immobilization these fractures unite and the density of the bone is restored to normal. Temporary avascularity may lead to aseptic necrosis, however, if the revascularization process is inadequate or disturbed.

The author advises fixation of the arm from the distal palmar crease to the elbow, with the proximal phalanx of the thumb included. The patient is encouraged to use the hand as much as possible. The cast is worn until the fracture is healed. It may have to be replaced from time to time, however. No nonunions are reported in this series.

³⁹¹ Obletz, B. E. Fresh Fractures of the Carpal Scaphoid, *Surg., Gynec & Obst.* 78: 83-90 (Jan.) 1944.

Allen ³⁹² found 6 cases of fracture of the carpal navicular bone in fifty-seven routine examinations of the wrist during a six month period. Clinical diagnosis of fracture of the navicular bone was made in only 1 case. Most of the fractures were diagnosed as sprain of the wrist.

Inasmuch as correct diagnosis and adequate immobilization are necessary for cure, an early diagnosis is important. In case of doubt, both wrists should be examined roentgenologically in anteroposterior views, lateral views and oblique views. Fibrous union, rather than bony union, often occurs.

Sometimes it is difficult to determine whether the fracture is old or recent. Decalcification, absorption of bone along line of fracture, efforts at repair or other signs may give a clue as to the age of the fracture, and each sign should be looked for and evaluated.

Henry ³⁹³ presents a good paper on fractures of the carpal scaphoid bone, calling attention to the fact that the lesion is frequently overlooked. Careful roentgenologic study of every "sprained" wrist in which pain persists longer than one week should be made. The roentgenogram is taken with the hand in sharp ulnar deviation, which brings the scaphoid bone into clear view and reveals many fractures which are missed with the usual position. During a five year period in a large industrial plant he was able to find 12 cases, whereas during a four month period at a large receiving and embarkation base he was able to find 22 cases. In practically all cases there is the same history of falling on the hand. He feels that the final result does not depend on immobilization or conservative treatment but rather on the site of fracture in the bone and whether or not the injury has destroyed or impaired the circulation to the bone, which is inadequate at best. Each fracture should be treated as an individual problem and the prognosis determined accordingly. Complete excision of the entire bone, done early, gives the best results. All dislocations of the scaphoid bone should be excised. Complete fracture through the middle to the inner third of the bone with displacement should be excised. Any crushing or comminution of the scaphoid bone should be treated by complete excision of the bone. Fissure fractures and fractures with no displacement may be treated conservatively.

In the industrial cases there was an incidence of 25 per cent of nonunion, and in the military cases 32 per cent of nonunion was reported [ED NOTE (L D B) —This author's treatment is not so conservative as that advocated by the other writers.]

³⁹² Allen W. F., Jr. Fractures of the Carpal Scaphoid. *Mil Surgeon* **93** 464-467 (Dec) 1943.

³⁹³ Henry M. G. Fractures of the Carpal Scaphoid Bone in Industry and in Military Service. *Arch Surg* **48** 278-283 (April) 1944.

through the lateral masses of the atlas, falls anteriorly and may cause flexion of the neck and a glide of the axis forward. The axis may subluxate on the third cervical vertebra, or the strong group of posterior muscles may fracture the lamina or both may happen.

Conversely, any forced hyperextension at this level must be over the wedge of the articulation with the third cervical vertebra, and, if the force is great, backward displacement is possible after fracture of the body or tearing of the ligaments.

Prominence has been given this lesion, since out of the 52 cases of fractures of the cervical portion of the spine there were 6 at this level and the only real fractures of the lamina occurred in the axis and accounted for 4 of the 6 cases.

In a case of fracture dislocation, every effort should be made to reduce it completely and maintain position, even though a good functional result is possible without complete replacement.

Chronic arthritis may cause a special liability to injury to the cord in older people who fall heavily and fracture the lower part of the cervical column. Roentgenologic evidence of displacement may not be found, even though the patient may have complete paraplegia.

Easton and Sommers⁴⁰⁰ present a series of 800 cases from six Ontario hospitals showing the incidence of fractured vertebrae in metrazol therapy. The incidence of fracture was 26.1 per cent. These occurred about twice as frequently in men as in women and the number of vertebrae affected was greater in men. They believe this to be due to the greater muscular development in men. The incidence of fracture was greater in patients under 21 years, probably because at that age the full strength has not yet been attained. All fractures were in the dorsal portion of the spine, the fifth vertebra being the most frequently affected. All fractures were of vertebral bodies, the transverse and spinous processes were not affected. No dislocation occurred. No preexisting pathologic change, such as kyphosis, scoliosis or arthritis, increased the tendency to injury, but osteoporosis is a definite contraindication to metrazol therapy. In the cases in which curare was used to diminish the severity of the convulsion, the incidence of fracture dropped from 26.1 to 0.625 per cent. These also showed a decrease in the degree of compression and the number of vertebrae involved.

Ellis⁴⁰¹ reviews the differential diagnosis of changes of the vertebral bodies. Because of the construction of the spinal column, the majority

400 Easton, N. L., and Sommers, J. Vertebral Fractures in Metrazol Therapy With and Without Use of Curare as Supplement, *J. Nerv. & Ment. Dis.* **99**: 256-263 (March) 1944.

401 Ellis, J. D. Compression Fractures of Vertebral Bodies and Other Changes Mistaken for Them, *J. Bone & Joint Surg.* **26**: 139-145 (Jan) 1944.

of compression fractures occur at the thoracolumbar junction. Since the force exerted on the superior part of the vertebral body is greater than that on the inferior part, almost invariably the fracture shows in the upper half of the vertebral body. Hollis Porter found only 1 fracture of the lower half of the vertebral body in a review of 500 consecutive compression fractures of the spine in which the arches were intact. The differentiation between old healed compression fractures and healed non-traumatic lesions is that in the fractures the wedging is roughly preserved and still affects the upper half only and the bone seldom resumes the appearance of the unaffected lower half. It has been shown by earlier research that general spondylosis and osteophyte production in the spine do not result from compression fractures of the vertebrae.

The wedged body of juvenile osteochondritis is distinguished from fracture in these ways: 1. The location is usually in the eighth to the tenth thoracic or the fifth lumbar vertebra. 2. Both upper and lower marginal rings are affected, and invariably there is a slighter degree of change in the adjacent vertebrae. 3. The general contour of the centrum is affected. 4. Scheuermann's nodes may appear. 5. Subsequent kyphosis is less angulated and involves both ends of the centrum.

Scheuermann's nodes may be differentiated from fractures because: 1. Nodes are most frequently found in the lower lumbar region, while fractures appear in upper lumbar and lower thoracic vertebrae. 2. The zone of separation is wide and clear, while a fracture shows irregular edges. 3. The node is larger than the usual marginal ring fracture. 4. More dislocation is evident in nodes. 5. The general contour of the centrum is unchanged with a node. 6. A fracture is due to a single injury, while a node is the result of abnormal lumbar extension strain.

Mamzer⁴⁰² reviews 63 cases of compression fracture of lumbar vertebrae, of which 32 were at the dorsolumbar junction, 22 of the second lumbar vertebra, 6 of the third lumbar vertebra and 3 of the fourth and fifth lumbar vertebrae.

A fracture of the vertebrae may be asymptomatic. The following signs and symptoms are indicative of a fracture of the vertebrae: (1) localized pain over the fracture site, (2) muscular rigidity of spinal muscles, (3) inability to stand erect, (4) weakness of the back, (5) retarded flexion at the fracture site and (6) presence or lack of presence of girdle pains.

Anteroposterior and lateral roentgenograms are essential to show fracture and degree of dislocation. Forty-five degree oblique roentgenograms may also be of value. Gentle handling of the patient with as little moving as possible is necessary during the roentgenographic studies.

⁴⁰² Mamzer, I. S. Compression Fractures of Lumbar Vertebra Without Cord Involvement. *Am. J. Surg.* 64:115-117 (April) 1944.

The treatment used in these cases was hyperextension, with forcible manipulation of the fracture and application of a plaster jacket as described by Davis

Further treatment consisted in recumbency for three to fourteen days, after which the patients were allowed to be ambulatory. Casts were worn for four months and were followed by adequate braces. Postural exercises were started after removal of the cast. The majority of patients returned to their former occupations in five months.

A review of 19 cases of fracture of transverse processes of the lumbar vertebrae treated with local injection of procaine hydrochloride and early mobilizing exercises is presented by Nicholson and Allan⁴⁰³

The diagnostic signs noted in these cases were list of the trunk to the affected side, painful flexion of the thigh against resistance on the affected side, discomfort increased by standing on the leg of the unaffected side and local tenderness and muscle spasm in the region of the injury.

Treatment consists in injection of 10 cc of 1 per cent procaine hydrochloride solution into the region of the fractured transverse process as soon as the diagnosis is made and repeated on the second, fifth and eighth days if pain and muscle spasm persist. In no case has it been possible to demonstrate the presence of a hematoma at the fracture site. Exercises are instituted immediately after injection and consist in active hyperextension of the spine with the patient in the prone position, rotation of the shoulders in sitting position, lateral bending of the trunk and touching the finger tips to the floor in standing position. Each of these exercises is performed fifteen times, and they are repeated twice daily. Heat and light massage are given daily during hospitalization.

All patients without complicating injuries are kept ambulatory and have returned to duty in an average of ten days. The earlier treatment is started, the less time the patient is off duty.

The authors believe that, in accordance with the observations of Leriche, procaine eliminates pain, permits early mobilization and blocks vasomotor phenomena. Even though these patients may be symptom free in an average of ten days, the torn muscles and fascial structures are not yet completely repaired.

[ED NOTE (L D B)]—The experience of Dr Nicholson and Dr Allan in treating fractures of lumbar transverse processes is worthy of note. Following their directions, I treated unilateral fractures of three transverse processes in a halfback on a college football team. Two weeks following the injury the patient ran 65 yards (59.4 meters). 45

403 Nicholson, J. T., and Allan, J. H. Fractures of Transverse Processes of Lumbar Vertebrae, *U S Nav M Bull* 42 780-785 (April) 1944

yards (41.1 meters) and 19 yards (17.3 meters) for touchdowns and passed 18 yards (16.4 meters) for a fourth touchdown, to win the game 26 to 19. He completed the season without difficulty. Roentgenograms five weeks following the injury showed satisfactory union of all three fractures.]

Pusitz and Thompson⁴⁰⁴ believe that 70 per cent of patients with compression fractures of the spine may return to their regular work provided there is complete reduction of the fracture, immobilization and proper fixation for long enough time and a program of muscle education carried out.

Reduction of the fracture should be done as early as possible, since delay makes the procedure more difficult and even incomplete. Even if complete reduction is not obtained, the rest of the routine should be carried out, as it will give a better end result.

The hyperextension cast is the best form of complete fixation. Movements of the unaffected joints is started as soon as patient recovers from the operation, usually in twenty-four to forty-eight hours. At the end of one month, the ambulant treatment will be started, the length of time the patient is out of bed being gradually increased until in six to eight weeks he is up as much as he desires.

The complete routine of the ambulant method is (1) from the beginning, movement of all joints not immobilized, (2) breathing exercises, (3) hyperextension of the head and shoulders, with the patient in the prone position, (4) hyperextension of the hip (single leg raising, then both), (5) with the patient strapped to table in the prone position, flexion of the body on the hips, (6) gluteal exercises, and (7), with the patient on his back, alternate straight leg raising.

In most cases the fracture will be healed when the cast is removed, in three to six months, and no support will be needed. If pain persists, exercises for mobilization of the spine are given as follows: (1) routine postural exercises, (2) in sitting position with hips abducted and body flexed on hips, flexion of the spine by placing the head between the knees followed by extension of the spine and (3) lateral flexion to the side opposite the muscular tightness.

Fractures of transverse processes should be treated by adhesive strapping if only one or two processes are fractured and there is little evidence of damages to soft tissues. If more processes are fractured, a plaster jacket should be applied. In either case active exercises are started from the beginning as described for fracture of vertebrae. Whether or not

404 Pusitz M. E. and Thompson I. E. Physical Therapy in Compression Fractures (Without Cord Injury), *Physiotherapy Rev.* 24 51-56 (March-April) 1944

these fractures unite is of no consequence, but it is important to prevent massive formation of adhesions by active muscle education

Fractures of the Pelvis—Howell⁴⁰⁵ reviews pelvic fractures. The complications in their order of importance are shock, injury to the urinary system, paralytic ileus, injury to nerve trunks and injury to the rectum. Hemorrhage from trauma to large vessels is rare.

All patients with pelvic fractures should be placed on a firm mattress with fracture boards or on a Bradford frame. Patients with fractures of individual bones without a break in the continuity of the pelvic girdle should be strapped with adhesive. [ED NOTE (L. D. B.)—The strapping may cause more discomfort than the fracture.] After three to four weeks in bed, they may be allowed to use crutches, with a canvas belt. Normal function may be expected in ten to twelve weeks.

When the fracture causes a break in the continuity of the pelvic ring, the aforementioned treatment may be carried out if there is no displacement. If displacement has occurred, the hammock and spreader as described by Nolan and Conwell may be used with traction to one or both legs. The patient is allowed up on crutches after six to eight weeks with a pelvic girdle, and weight bearing is started in ten to twelve weeks. When these patients are not kept hospitalized, a double spica plaster cast may be applied after two to three weeks of the treatment mentioned and worn for six to eight weeks.

The double vertical fractures of the pelvis (Malgaigne fractures) and multiple fractures are best treated by the pelvic suspension frame with hammock and traction. Frequent roentgenologic examinations must be made, and if correction of the deformity is not accomplished manipulation with the patient under anesthetic may be done.

Musgrove⁴⁰⁶ reports a fracture of the pelvis in a 40 year old man, a sedentary worker, who slipped on the ice and "did the splits." He experienced immediate and moderately severe pain in the adductor region of the right thigh. Walking aggravated the pain, and the patient limped considerably. In the hospital, he was thought to have a strain of the right adductor longus muscle at its origin from the pelvic bone and was treated with hourly hot packs. One week later pain persisted, and a roentgenogram revealed a fracture line across the inferior pubic ramus with two adjacent condensed lines, interpreted as buckling of the cortex.

After rest in bed for one month, the patient walked with little pain. Sixty-eight days after the accident he had been free of pain for two weeks, and a roentgenogram showed a fracture line transversing the

⁴⁰⁵ Howell, J. B. Pelvis Fractures, *Mississippi Doctor* **21** 273-276 (March) 1944.

⁴⁰⁶ Musgrove, J. E. Unusual Fracture of the Pelvis, *Canad. M. A. J.* **50** 446-447 (May) 1944.

right inferior pubic ramus, with considerable callus formation. The author notes that these roentgenograms are almost identical with those of march fracture of the inferior pubic ramus described by Nickerson. Possibly the mechanism of this fracture is that the adductor magnus muscle caused a traction fracture in attempting to break the fall. If this is correct, similar repeated minimal strains which a soldier is liable to incur during training may be the cause of the march fracture of the pubis described by Nickerson.

Of 780 cases of fractures of the pelvis reviewed by McCague and Semans,⁴⁰⁷ 133 patients, or 17 per cent, had accompanying rupture of the urethra or bladder. Of these, 99 had an intrapelvic urethral rupture, 1 a rupture of the anterior urethra, 22, rupture of the bladder, 11, combined urethral and vesical rupture.

Shock is severe in such cases. Cystostomy is required early to prevent urinary extravasation. Perineal drainage is usually necessary to prevent infection of the soft tissues about the urethra and the bladder. In the 133 cases studied in this series, there was a mortality of 23 per cent.

Adlington⁴⁰⁸ presents a case of fracture dislocation of the symphysis pubis and dislocation of the right sacroiliac joint complicating rupture of a kidney and the spleen, with recovery. Other complications include bilateral bronchopneumonia, separation of wound and fecal fistula. This extensive injury to a 36 year old munitions worker resulted from being trapped between a 57 ton (51,710 Kg) jib crane and a stack of 20 tons (18,144 Kg) of 8 inch (20.3 cm) naval shells.

On entrance to the Sheffield Royal Infirmary, the patient's blood pressure was 95 systolic and 75 diastolic, the pulse rate was 96 and of poor volume, and the abdomen was tender, slightly distended and immobile. There was tenderness over the lumbar portion of the spine, but there was no sign of injury to the central nervous system. There was remarkably little bruising or abrasion.

Immediate splenectomy and nephrectomy were performed, with concurrent treatment of shock. Treatment of the dislocated pelvis consisted in immobilization between sandbags and use of a pelvic binder. The patient could walk rather well and was free from pain on dismissal.

Fractures of the Femur —Swart and Miyakawa⁴⁰⁹ give their experience with the treatment of one hundred and eighty-four fractures of the femur in 179 patients. For twenty-eight fractures of the neck of the

⁴⁰⁷ McCague F. J. and Semans J. H. The Management of Traumatic Rupture of the Urethra and Bladder Complicating Fracture of the Pelvis, *J. Urol.* **52** 36-41 (July) 1944.

⁴⁰⁸ Adlington S. R. Dislocations of the Pelvis with Traumatic Rupture of Kidney and Spleen *Brit. J. Surg.* **31** 407-408 (April) 1944.

⁴⁰⁹ Swart H. A. and Miyakawa G. Fractures of the Femur. Results of Treatment of 179 Patients, *Am. J. Surg.* **65** 221-225 (Aug) 1944.

femur, the results were considered excellent in 17 per cent and good in 39 per cent. The authors feel that failures most often result from damage to the blood supply at the time of the accident.

In treatment of the 36 intertrochanteric fractures in this group excellent results were attained for 27 per cent and good results for 30 per cent. The most favored form of treatment was well leg traction by the Roger Anderson or the Carl Jones method.

There were 23 fractures in the upper third of the shaft, with excellent results in 34 per cent and good results in 39 per cent. Skeletal traction was moderately successful in most cases, but when there was a short upper fragment a vitallium plate on the bone was often necessary.

The 69 fractures of the middle third of the femur led the authors to believe that Russell traction was the best form of treatment.

There were 28 fractures of the lower third of the femur, and these were best treated by use of two or even three Kirschner wires in order to correct all the various displacements.

Hart ⁴¹⁰ describes the best type of treatment for every type of fracture which can occur in the adult femur. He emphasizes correctly the importance of preserving function of the joint and muscle tone during the long period of immobilization needed for most of these fractures. An especially good point is the author's preference for placing Kirschner wires through the upper end of the tibia rather than the lower end of the femur. Wires through the femur restrict the gliding mechanism of the femoral fascia, cause synovial and capsular adhesions and encourage quadriceps atrophy. [ED. NOTE.—The author speaks of keeping patients in bed with traction "until there is radiographic evidence of good bony union between the fragments." Stability of the fracture or its resistance to attempted bending will often be adequate before there is roentgenologic proof of callus formation, and it can be assumed that healing is far advanced whether the roentgenologic evidence is satisfactory or not.]

Bush ⁴¹¹ has treated 39 patients with fracture of the femur, using manipulation or preliminary traction followed by immobilization in a double hip spica. The author claims that hospitalization is shortened, care is eased and the children are more comfortable.

Briones Olivos and Gebauer ⁴¹² report on 12 cases of fracture of the femoral shaft treated by double skeletal traction. The place of transfixion with Kirschner wire is at the level of the anterior tubercle of the tibia and

410 Hart, V. L. Treatment of Fractures of the Adult Femur, *Mil Surgeon* **95** 379-384 (Nov.) 1944.

411 Bush, L. F. Treatment of Fractures of the Femur in Children, *Am J Surg* **64** 375-378 (June) 1944.

412 Briones Olivos, J., and Gebauer, T. Diaphysial Fractures and Their Therapy with Double Skeletal Traction, *Arch Soc cirujanos hosp* **13** 29-34 (June) 1943.

the distal fragment of the femoral shaft or the supracondylar fragment. Patients are placed on a hard bed with a Braun splint adapted to the traction procedure. Transtibial traction is maintained for an average of forty days and transfemoral or supracondylar traction for thirty days. A plaster of paris cast was applied to 11 patients to complete treatment.

The time required for recovery was seven months and twenty days. Two patients required operation, one because of delayed union in a compound fracture with interposition of muscle and the other because of formation of a vicious callus due to vicious bony union. These complications were not due to the method.

Hampton⁴¹³ describes in detail the importance of proper placement of the traction wire in the lower end of the femur and of the adjustment of overhead traction with longitudinal traction. There are excellent drawings to demonstrate the application of the Thomas splint and slings and of the means for leaving access to wounds. The external traction apparatuses were found not adaptable for treatment of battle fractures.

In World War I, compound fractures of the femur caused 17 per cent mortality. In the North African campaign, in one hospital there was 1 death in 83 cases. As the war moved into Italy, sepsis increased, but in another group, of 193 cases, there were only 3 deaths.

Jack,⁴¹⁴ working in the Middle East, found that patients with fractured femurs presented difficult problems. There were long ambulance journeys over rough roads, unpredictable delays and inadequate facilities for treatment en route. Consequently, special methods of transport of these patients had to be worked out to prevent shock and suffering while at the same time reasonable apposition of the fracture fragments was being preserved. An Australian hospital at Tobruk devised the plaster cast and splint combination ("Tobruk splint"), which solved this special problem better than any other methods. By use of adhesive skin traction and the Thomas splint with a supporting cast about the thigh and leg, these patients were transported with a minimum of discomfort until they could reach the base hospital. This is recognized as a compromise procedure, but it was the best that could be done for the patients in the unusual circumstances seen in the early African campaigns.

Automobile accidents, paratroop training and landing operations are the cause of a large percentage of fractures of the femur. MacPherson⁴¹⁵

413 Hampton, O. P. Observations on the Use of Balanced Skeletal Traction for Battle Fractures of the Femoral Shaft, *M. Bull. North African Theat. Op.* (no. 3) **2** 46-51 (Sept.) 1944.

414 Jack, E. A. Evacuation of the Fractured Femur, *Lancet* **2** 11-13 (July 1) 1944.

415 MacPherson, F. L. Symposium on War Surgery. Femoral Plating with Fixation by Townsend and Gilfillan Plate, *S. Clin. North America* **23** 1623-1626 (Dec.) 1943.

advocates treating the patients first by the application of skeletal traction through the distal end of the femur. If reduction is obtained in seven days, the traction is continued. When traction fails, the fracture is plated, with use of two Townsend and Gilfillian plates nested together to provide added strength. Large comminuted fragments are first fixed with a separate screw placed away from the site of plating. No external fixation is used. The author claims reduction in length of disability of 50 per cent over other methods. [ED NOTE (L D B) — Seven days is not long enough time to wait for reduction by traction.]

Charnley⁴¹⁶ analyzes the mechanical factors underlying the reduction and fixation of fractures of the femoral shaft. He contends that the criteria for good results are (1) correction of shortening and angulation and lateral displacement and (2) immobilization. He feels that fixed traction in a Thomas splint is the most satisfactory method. Detailed mechanical data are presented to prove his contention.

Masland⁴¹⁷ describes a splint for fractures of the femur which secures traction by a cast on the leg and countertraction by a pelvic ring. Pressure is increased by turnbuckles, which can be adjusted, to recover length of the extremity. This splint which he has used for twenty years is efficient in reducing and maintaining fractures. [ED NOTE — In the hands of such an experienced person as the author, this splint apparently functions well. It is difficult to see, however, how a less capable surgeon could avoid pressure sores on the foot or leg from this powerful turnbuckle traction.]

Fractures of the Leg — Savini⁴¹⁸ emphasizes again the importance of immobilization of fractures of the lower extremity preliminary to moving the patient. The particular appliance which he recommends is a board large enough to be placed under the patient and to support both lower extremities by suitable webbing straps. It certainly is a principle of "splint them where they lie," and it is worthy of reemphasis. The apparatus he suggests appears to be practical for lay use.

Curry⁴¹⁹ describes a novel type of splint for the lower extremity, made of a pneumatic encasement for the whole limb. It buckles about the injured extremity and provides even, steady support, with great relief from pain on movement. [ED NOTE — This is an ingenious idea and has merit if such splints can be manufactured at reasonable cost.]

416 Charnley, J. Mechanics of Reduction and Fixation of Fractures of the Shaft of the Femur, *Lancet* **1** 235-239 (Feb 19) 1944

417 Masland, H. C. Modern Fracture Deformity Reducing Splints, *Am J Surg* **66** 182-188 (Nov) 1944

418 Savini, C. Transportation of Patients with Fractures of Lower Extremities, *J Bone & Joint Surg* **26** 406-407 (April) 1944

419 Curry, G. J. A Pneumatic Leg Splint, *J A M A* **125** 966-968 (Aug 5) 1944

Blumenfeld⁴²⁰ reports 3 cases of serious complications following use of the Anderson skeletal fixation device for fractures of the leg. In the first case there was extensive infection of the soft tissues, sloughing and paralysis of the anterior tibial muscle. In the second case, infection developed later, but the peroneal palsy was evident from the first, which probably meant that the peroneal nerve was damaged when the upper pin was inserted. In the third case, infection of the soft tissues followed insertion of the pins. [ED NOTE—While these are extreme illustrations, they emphasize once again the dangers inherent in external fixation of fractures. In the hands of the experts and the principal proponents of this method, infection about the pins may be negligible. Still, any method of treatment of fractures must meet the stiff requirements of being suitable for use under varied conditions and in the hands of many different surgeons.]

Goldberg⁴²¹ describes a makeshift "walking heel" which meets the requirements of any kind of walking cast. A discarded rubber heel is nailed to a block of wood $\frac{5}{8}$ inch (1.6 cm) thick, 3 inches (7.6 cm) wide and $7\frac{1}{2}$ inches (19 cm) long. This is incorporated into the sole of the leg cast.

Ligament Injuries and Sprains About the Ankle—During the past year there have been many excellent articles concerning painstaking work in regard to treatment of injuries to ligaments about the ankle. Needless to say, there is still great discrepancy of opinion as to the proper method of treatment of the "sprained ankle." It should be emphasized that it is extremely important to differentiate between minimal damage to a ligament and major injuries involving loss of integrity of the ligaments. This is brought out by Ball and Egbert,⁴²² who call attention to the fact that in the normal anteroposterior roentgenogram of the ankle joint there cannot be a translucent zone between both the talus and tibia and the talus and fibula. If such a zone is visible on both sides, it indicates damage to the tibiofibular ligament, with widening of the ankle mortise. They point out that failure to recognize such a space will result in inadequate treatment, with permanent disability.

Wright and Parker⁴²³ also emphasize the importance of separating so-called simple sprains from serious injuries to ligaments. They state that in their opinion, failure to recognize complete rupture of a liga-

420 Blumenfeld, E. Footdrop Following Skeletal Fixation, Bull U S Army M Dept., December 1944, no 83, pp 73-76.

421 Goldberg, D. A Practical Walking Cast for Use Under Wartime Conditions, Mil Surgeon **95** 151-153 (Aug) 1944.

422 Ball, R. P., and Egbert, E. W. Ruptured Ligaments of Ankle. Roentgen Sign, Am J Roentgenol **50** 770-771 (Dec) 1943.

423 Wright J. M., Parker, L. O., and Lehan, T. R. Sprained Ankles, U S Nav M Bull **42** 1309-1313 (June) 1944.

ment, with subsequent inadequate immobilization, is largely responsible for chronic and recurrent sprained ankles. In many of their cases complete rupture of the lateral ligament of the ankle was found much more commonly than rupture of the internal ligament. They recommend an anteroposterior roentgenogram of the ankle made with the foot passively adducted, so to put strain on the lateral ligament, which will permit some subluxation of the talus in the ankle mortise if the lateral ligament is torn. In their opinion, this is sufficiently important to justify the use of an anesthetic in order to determine a rupture of a ligament in a doubtful case. Anesthesia is induced by injection of 20 or 30 cc of 1 per cent procaine hydrochloride solution. If rupture of a ligament is found, a nonpadded plaster cast with walking stirrup is applied. Immediate walking is urged, and the cast is left in place for six weeks followed by adhesive strapping for another two weeks. For the so-called simple sprained ankle, without serious ligament injury, a pressure bandage with injection of procaine hydrochloride solution, massage and early use is recommended.

A contrary opinion is expressed by Webber,⁴²⁴ who advised that there are distinct disadvantages to the three common methods of treatment for a sprained ankle, namely, rest in bed, exercise and strapping. He indicates that muscle spasm, pain, venous stasis and lacerated ligaments are the common pathologic findings, and he adds that vasoconstriction is increased by strapping while muscle spasm and pain are increased by early weight bearing and pull on the injured ligament. He feels that putting the patient on his feet too soon after injury will cause other chronic foot conditions, such as warts, calluses and synovitis. His technic varies somewhat from that usually employed in that he recommends injection of procaine hydrochloride to the talocalcaneal joint space. By careful roentgenologic study, he was able to demonstrate in many cases a distinct widening of the talonavicular and the calcaneocuboid joint space, probably by the pressure of a hematoma, and, in his opinion this accounts for the deep aching in the foot and up the back of the leg which was observed in his early cases, in which the patient did not have the benefit of talocalcaneal injection. After the injection, the patients were sent back to full duty, with apparently satisfactory results.

Cleveland, Wilhen and Doran⁴²⁵ present an interesting paper, pointing out the contrast in treatment of soldiers and civilians. Since a soldier can be kept under careful observation, because he must be kept

424 Webber, J T. Ambulatory Treatment for Sprained Ankles, *West Virginia M J* 40:176-178 (June) 1944.

425 Cleveland, M, Wilhen, L J, and Doran, P C. Treatment of Undisplaced Fractures at Ankle Joint, *Bull U S Army M Dept*, June 1944, no 77, pp 103-105.

in the hospital until his return to active duty, and can be kept entirely under the control of the medical staff, medical officers have attempted to reduce the hospital stay by elimination of the early period of immobilization. In a group of patients with fractures about the ankle joint, notably the lower part of the fibula, without displacement, it has been observed that following use of a plaster cast the period of rehabilitation after the cast is removed is often longer than the period of immobilization itself, a period characterized by swelling, pain on weight bearing and limitation of motion. Two parallel series of patients were observed, 32 patients receiving immobilization and 32 patients receiving a regimen consisting in rest in bed, elevation, ice packs, early active mobilization and weight bearing as soon as soft tissue damage had apparently subsided. No manipulation was carried out, and careful roentgenologic study was made to determine complete integrity of the ankle mortise. Treatment of the injury to the joint itself was considered subordinate to early weight bearing and was supplemented by hydrotherapy, massage and gentle manipulation. In this series, the number of days of duty lost by immobilization in plaster followed by physical therapy was 57.3 days, while the time lost in the series of patients without immobilization was reduced to 35.7 days. It was emphasized that complete and continuous control of the patient is essential.

Because of extreme disability which follows improperly reduced fractures of the ankle, Burgess⁴²⁶ has made it a rule in recent years to do "routine open reductions of all fractures of the ankle with displacement." Fractures of the medial malleolus are reduced and anchored by a single vitallium screw. Bimalleolar fractures are treated in the same way, and the vitallium screw in the medial malleolus is sufficient to hold both fragments in proper position. Fractures of the lateral malleolus are reduced and anchored by passing a vitallium screw through the distal fragment and into the lower end of the tibia. Trimalleolar fractures (with the posterior tip of the tibia fractured off) are reduced and vitallium screws placed through the medial malleolus and the posterior malleolus. Diastasis of the inferior tibiofibular joint is treated by a screw placed through the lower end of the fibula into the tibia in an oblique direction (to prevent stripping of the screw threads).

After using these methods in 46 cases, Burgess feels that the results are better because the foot is held in the normal neutral position in the cast, early weight bearing in a cast is possible and the entire period of cast immobilization is shorter.

[ED. NOTE—While the author's points are well taken we have always felt that fresh fractures of the ankle were among the easiest to reduce. It is true that walking casts have no place in the treatment

⁴²⁶ Burgess, E. Fractures of the Ankle, *J. Bone & Joint Surg.* **26**: 721-732 (Oct.) 1944.

of fractured ankles unless the fragments are anchored by screws. Most nonunions of ankle fractures result from too early weight bearing. If this method eliminates late stiffness of the ankle when used by many surgeons, it has merit. On the other hand, it seems radical to advise "open reduction of all fractures of the ankle with displacement"]

O'Shea ⁴²⁷ reports 2 cases of fracture of the calcaneus with dislocation of the subastragaloid joint, pointing out that this rather unusual type of injury is not to be confused with total dislocation of the talus. He indicates that careful roentgenologic study will reveal the pathologic changes and that each patient must be sharply individualized for the method of treatment. It was emphasized that this gross displacement causes pronounced impairment of circulation of the foot, and O'Shea discusses at length the blood supply in this area. The ankle mortise is not disturbed, the dislocation occurring between the talus and calcaneus and the talus and navicular bones, with the probability of tendons and ligaments being wedged into the luxated joint. This is often attended by other fractures of the foot. He particularly stresses the importance of early reduction of the joint, with the patient under general anesthesia. Following reduction, immobilization in a plaster cast extending from the mid thigh to the toes, with the foot at a right angle, should be used and maintained for eight weeks. If there should be any question about the completeness of reduction, open intervention should be done. Should reduction be long delayed, open reduction with subastragaloid arthrodesis is the procedure of choice.

Gill ⁴²⁸ presents a description of a method for reduction and fixation of fractures of the os calcis, telling about reduction by skeletal traction with the patient lying on his face in order to permit better accessibility for the traction. This is followed by fixation with pins through the cuboid and the talus bone and a sagittal pin through the os calcis. If this fracture is not of a comminuted type, only the sagittal pin will be necessary. [ED. NOTE—Details must be sought in the original article.]

McBride ⁴²⁹ describes a method of treating fractures of the calcaneus bone by the use of three pins, threaded bars and nut traction tubes. A pin is placed through the tibia 4 inches (10 cm) above the ankle, another through the base of the metatarsals and the third through the tuberosity of the calcaneus.

427 O'Shea, M. C. Subastragaloid Dislocations, with Report of Two Cases of Dislocation of Subastragaloid Joint and Fracture of Os Calcis, *New York State J. Med.* **44** 49-55 (Jan. 1) 1944.

428 Gill, G. G. Three Pin Method for Treatment of Severely Comminuted Fractures, *Surg., Gynec. & Obst.* **78** 653-656 (June) 1944.

429 McBride, E. D. Fractures of the Os Calcis, *J. Bone & Joint Surg.* **26** 578-579 (July) 1944.

Compound Fractures and Battle Fractures—Macdonald's⁴³⁰ report covers cases observed during 1941, 1942 and 1943 at a New Zealand hospital unit in the Middle East. His observations early in the war showed that it was a mistake to attempt to suture wounds primarily at front line hospitals. Surgeons soon found that wounds thus treated always became infected.

Also early in the war debridement or "excision of the wounds" often led to unnecessarily drastic removal of soft tissues. Too much petrolatum gauze was used in wounds in an effort to produce a "petrolatum plug." By all odds, it was found that the Thomas splint was the safest and the most efficient device for the transportation of patients with fractured femurs. The most troublesome wounds were those received in mine accidents, with compound fracture of the bones of the feet.

Jeffrey⁴³¹ reports on the use of penicillin in Italy. In January to June 1944, the use of penicillin was started for all severe compound fractures. In the forward areas, wounds were excised, insufflated with penicillin-sulfathiazole powder and packed open with petrolatum gauze. At the base hospital, the wounds were partially sutured, and patients were given penicillin systemically in doses of 15,000 units every three hours for five to ten days.

One hundred and fifty patients with fractures of the femur were so treated, and only 25 per cent showed persistent minor infections three months later. Adequate dosage of penicillin and early partial suture of wounds produced much less dense scars and more rapid healing of the fractures.

Jeffrey and Thomson⁴³² report that gas gangrene increased as the war moved from the Middle East (3.4 per 1,000) to Tunisia (6.7 per 1,000) to Italy (10 per 1,000). The mortality was about 50 per cent.

Thirty-three patients in Italy in the spring of 1944 were treated by radical incision, gas gangrene antitoxin and penicillin. Twelve of the patients died, but in some instances death occurred from late renal failure. In all cases there was a striking arrest of the gangrenous process, although late toxic effects from the infection were often observed.

⁴³⁰ Macdonald, A. Observations on Battle Casualty Compound Fractures and Joint Injuries in the Middle East, New Zealand M J **43** 172-176 (Aug) 1944.

⁴³¹ Jeffrey, J S. Battle Casualty Fractures in Italy. Treatment with Penicillin, Brit J Surg (supp) **32** 144-147 (July) 1944.

⁴³² Jeffrey, J S, and Thomson S. Gas Gangrene in Italy. A Study of Thirty-Three Cases Treated with Penicillin, Brit J Surg (supp) **32** 159-167 (July) 1944.

McEwan and Bickerton⁴³³ report on 12 battle casualty fractures of the femur treated by intramuscular injections of penicillin at an orthopedic center in Italy in 1944. Nine of the fractures healed primarily, and the bony union proceeded normally. The other three fractures were still open after three months but in only 2 was there any evidence of infection of the bone.

Mech⁴³⁴ states that penicillin is the most potent antibacterial agent available for the treatment of compound wounds. The author used large doses, 25,000 units every three hours, and felt that this was more effective than use of smaller doses. Equally important is close consideration of the patient's general nutritional status.

Moore⁴³⁵ gives a good sketch of the development of knowledge of the growth of bone and of the evolution of bone grafting. There are, in addition, excellent diagrams of the various bone-grafting methods which have been proposed in recent decades. The modern massive bone grafts immobilized with metal screws and supported by external casts provide a high percentage of unions in old ununited compound fractures.

Snyder's⁴³⁶ statistics show that 60 per cent of the battle casualties admitted to Fifth Army hospitals had wounds of the extremities. Under battle conditions, all patients were stripped of clothing to make possible complete examination of the body. This was necessary to prevent the overlooking of small wounds. In general, all treatment was given with the patient under general anesthesia.

Wobbling rifle bullets produced explosive effects in tissues similar to those produced by high explosive fragments. Hence all such wounds required excision of tissue more extensive than the simple debridement. Primary nerve suture was not satisfactory, but damaged nerves were identified and reported in the patient's record. Primary tendon suture was likewise unsatisfactory. Clean through and through wounds required adequate exploration and drainage to prevent gas gangrene.

Adequate early operation was the only way by which serious complications such as cellulitis, gas gangrene and abscesses could be prevented.

433 McEwan, R. J. B., and Bickerton, J. J. Battle Casualty Fractures of the Femur. Treatment with Penicillin, *Brit J Surg* (supp) **32** 154-158 (July) 1944.

434 Mech, K. F. Wound Healing in Compound Fractures and Repair of Bone Defects, *J Bone & Joint Surg* **26** 442-447 (July) 1944.

435 Moore, J. R. Bridging of Bone Defects in Compound Wounds, *J Bone & Joint Surg* **26** 455-468 (July) 1944.

436 Snyder, H. E. War Wounds of the Extremities, *M Bull North African Theat Op* (no 5) **1** 35-36 (May) 1944.

Fruchand⁴³⁷ criticizes the English method of treating wounds of joints by suturing the capsule, because too often secondary infection develops. He prefers the French method of drainage of joints so that synovial fluid can flush the wound as it escapes. This is done by wide arthrotomy and suture of the synovial membrane to the skin. In the knee, it is simple to achieve such drainage. However, in the hip, elbow, wrist and ankle, there are bony structures within the joint (head of the femur, olecranon, carpal bones and astragalus) which interfere with proper drainage and which often need to be excised.

Postoperative immobilization is extremely important to prevent spread of the infection or secondary invasion of bacteria. Plaster casts accomplish this better than any other type of splint [ED NOTE (L D B)]—There have been numerous conflicting reports as to the treatment of war wounds of the joints. We shall reserve our opinion until final results are available.]

Carpenter⁴³⁸ found penicillin to be nontoxic and useful in combating the common infections. For local application, a solution of 250 units per cubic centimeter is used to saturate gauze packs which are inserted into the wound once daily. For the streptococcic and pneumococcic infections, 90,000 to 120,000 units is given daily. For the staphylococcic infections, more than twice this dose is required. In patients with chronic sepsis a negative nitrogen balance develops, and this must be overcome to insure normal wound healing. Hemoglobin deficiency is especially prone to retard healing.

For acute compound fractures use of penicillin should be begun immediately, even before the debridement operation. With this powerful new antibacterial agent it is possible that compound fractures can be saved from infection even ten to twenty-four hours after the accident. Penicillin is a more effectual antibacterial agent than the sulfonamide drugs in both the prevention and the cure of infection.

Forbes and Goligher⁴³⁹ give a detailed discussion of the case of a 24 year old man who had a compound fracture of the tibia and fibula. The patient received his injuries during a naval engagement. After a month, the fracture wound was still heavily infected, and when the first cast was changed the patient's temperature rose rapidly and signs of septicemia occurred. Chemotherapy was ineffective, and the leg was amputated. Aerobic culture of the blood was sterile, but a gram-negative filamentous organism resembling *Bacterium necrophorum* was

437 Fruchand, H. Wounds of the Joints, *Lancet* 2 235-238 (Aug 18) 1944

438 Carpenter, G K, and Mech, K F. The Role of Penicillin in the Treatment of Compound Fractures, *New York State J Med* 44 1886-1890 (Sept. 1) 1944

439 Forbes, G B, and Goligher, J C. Necrobacillosis in Man, *Lancet* 1: 399-401 (March 25) 1944

isolated from pyemic abscesses and was later grown anaerobically from the blood. On the patient's death, after nearly twelve weeks of illness, multiple pyemic abscesses were found in the lungs and under the skin.

Bact. necrophorum is widely distributed and causes a variety of diseases in animals. Though it has been recovered from the healthy human colon and also from the colon in ulcerative colitis, few cases are on record in which it has been clearly pathogenic to human beings. In this particular case discussed, the source of the infection was not known.

King and Brewer⁴⁴⁰ discuss in some detail gangrene complicating fractures about the knee. They presented 4 of their own cases which were followed by careful dissection of the amputated foot, the cause of complication in 2 of the cases being thrombosis of the main vessels and in 2 of the cases being actual rupture of the vessels. There were 2 cases with fracture of the upper portion of the tibia, 1 of the lower part of the femur and 1 of fracture dislocation of the knee. A careful analysis of the dissection was carried out in each case and indicated that the blood vessels at the knee were particularly susceptible to damage owing to their close proximity to the bone and to their complete immobilization. The extreme importance of early recognition is emphasized, particularly the effort to distinguish between thrombosis and rupture. They believe that exploration should be carried out immediately if rupture is diagnosed, since delay will add to the danger of increased gangrene and increased fatality. Operation, as a rule, is ligation rather than repair of the vessels indicated. On the other hand, should thrombosis be diagnosed, therapy should be instituted toward support of the ischemic tissue by advancing the collateral circulation. In any event, early and prompt reduction of the deformity is essential and should be carried out with the patient under anesthesia. Lumbar sympathetic block should be considered as an aid to circulation and repeated as often as indicated. Local heat should be applied only after careful consideration of the metabolism of the affected part. Drugs also will be of help. Amputation is carried out as soon as demarcation occurs. [ED. NOTE—This is an excellent study of this problem and merits careful reading of the original article.]

West⁴⁴¹ advocates three methods of treatment of compound fractures of the femur: (1) slinging of the injured limb in the Thomas splint with Pearson attachment and with skeletal extension (this method is the one he uses widely), (2) immobilization of the injured limb in an ordinary Thomas bed knee splint with fixed adhesive skin traction

⁴⁴⁰ King, J. M., and Brewer, B. J. Gangrene Complicating Fractures About the Knee, *Surg., Gynec. & Obst.* **78** 29-35 (Jan.) 1944.

⁴⁴¹ West, E. F. Treatment of Compound Fractures of Femur in Battle Casualties at General Hospital, M. J. Australia **1** 193-196 (March 4) 1944.

(this method is advocated in cases in which wounds interfere with the use of the Steinman pin and in some transverse fractures), and (3) immobilization of the injured limb in a single or double hip spica (this is used in cases in which considerable loss of bone has occurred and bone contact must be maintained by shortening and in cases in which ankylosis is desired in the optimum position) The author describes each method in considerable detail

The results of treatment in more than 500 cases of war fractures of the femur are reviewed by Yudin ⁴⁴² He advocates well performed, thorough débridement, intense local and general hemotherapy and closed plaster cast This method is used even in the presence of well developed infection

The operative principles are (1) wide excision of all injured and contused tissue, regardless of the presence of infection, (2) no drains, (3) continuous free drainage by means of counteropenings, (4) suture of the edges of the skin with surgical gut to the deep fascia, (5) rich abundant lavage of the wound with a mild soap solution, and (6) local chemotherapy and a closed nonpadded plaster of paris cast An hour and a half is allowed for each patient Three tables are set up On the first table traction is applied, spinal anesthesia is given and the wounded man is washed On the second table the operation is performed, and on the third the cast is applied The mortality in over 500 cases was 5.9 per cent Yudin credits Piragoff with first having used plaster in treating war fractures

Cantril and Buschke ⁴⁴³ report 9 cases of gas gangrene successfully treated by roentgen therapy with or without therapy with sulfonamide compounds Two treatments daily for several days were the usual dose varied according to the severity of the original infection

Two of the patients recovered without need for amputations, 1 required an amputation eighteen months later and 4 required amputations because of circulatory damage

The authors feel that sulfonamide drugs are of no benefit in controlling the progress of gas gangrene infection [ED NOTE—This report is more optimistic and more credible than some others on roentgen therapy for gas gangrene As is well known, the outcome often depends more on whether the infection is in the fascial spaces or in the necrotic muscle than on the therapy used Many physicians have felt that sulfonamide drugs were effective against the gas-producing anaerobes At any rate, all this discussion will be altered one way or

⁴⁴² Yudin, S S Treatment of War Fractures of Femur, Surg, Gynec & Obst **78** 1-8 (Jan) 1944

⁴⁴³ Cantril, S T, and Buschke, F Roentgen Therapy in Gas Bacillus Infection, Radiology **43** 333-345 (Oct) 1944

the other when the final evidence on penicillin therapy has been published]

Orr-Ewing and colleagues⁴⁴⁴ report a study of 32 patients with severe compound wounds, 18 of whom received sulfanilamide locally and 14 of whom did not. None of the patients received general sulfanilamide treatment. Direct bacteriologic examination of the wounds during treatment showed that for the first two weeks the sulfanilamide-treated wounds contained fewer bacteria than the controls. After two weeks there was little difference between the two groups. There was no clinical evidence that local sulfanilamide therapy affected the course of the infection. The wound flora was reduced, but there was no corresponding benefit to the ultimate result of the wound. [ED NOTE—These observations annul many of the beliefs of the early enthusiasts for local sulfanilamide therapy of compound wounds. Yet this is apparently a thorough study. The whole issue becomes less important, however, from the fact that general penicillin therapy seems destined to displace therapy with sulfonamide drugs in compound injuries.]

Kepl, Ochsner and Dixon⁴⁴⁵ report a case of gunshot injury of the thigh and a case of severe laceration of the upper extremity in each of which clostridial infections developed. In the first case treatment consisted in local application of calcium penicillin, and in the second local and general treatment was used after the arm was amputated.

In addition to prompt surgical treatment, the use of penicillin caused a rapid drop in toxic symptoms, and the wounds progressed to comparatively prompt healing. The authors make it clear that a good operation is still the prime essential to successful treatment of gas gangrene.

Furlong and Clark⁴⁴⁶ studied 140 compound fractures of the femur, 70 treated with penicillin and 70 treated by other methods. Penicillin was not used locally, but 15,000 units was given intramuscularly every three hours for three days and every four hours for two additional days. There were 7 deaths, 6 in the control series and 1 in the penicillin series. Eight thigh amputations were performed, 6 in the control series and 2 in the penicillin series. Penicillin as used in this series failed to control sepsis fully and did not diminish the incidence of chronic infection. Penicillin is not a substitute for surgical treatment. Closure of compound wounds is undesirable unless adequate drainage

444 Orr-Ewing, J., Scott, J. C., Masina, F. H., Trueta, J., and Gardner, A. D. Local Sulphanilamide Treatment of Fresh Wounds in Complete Plasters, *Brit J Surg* **32** 83-84 (July) 1944.

445 Kepl, M. F., Ochsner, A., and Dixon, J. L. Two Cases of Clostridium Welchii Infection Treated with Penicillin, *J A M A* **126** 96-98 (Sept. 9) 1944.

446 Furlong, R., and Clark, J. M. P. On the Use of Penicillin to Control Infection in Open Fractures of the Femur, *Brit. J Surg (supp)* **32** 147-154 (July) 1944.

is provided [ED NOTE—This interesting experiment, which was well controlled, confirms once again the point that penicillin is just an adjunct to surgical treatment in compound fractures]

Brown⁴⁴⁷ shows graphically how the best repairs of bones and tendons often fail because of defective skin covering the damaged areas. Sclerotic skin with poor blood supply makes an extremely ineffective barrier to outside infection. Recurrent ulceration over a fracture or bone graft is an invitation to failure. Hence the advice of this eminent plastic surgeon on the use of skin grafts over scarred areas is well worth heeding.

March Fractures or Fatigue Fractures—Jones⁴⁴⁸ presents 3 cases of march fracture of the inferior pubic ramus. Such fractures are characterized by absence of trauma and absence of any other break in the pubic ring. In all these cases there were insidious onsets, with pain in the adductor region of the thigh. The fractures did not respond to physical therapy, and roentgenograms revealed rarefaction and surrounding periosteal reaction along the inferior pubic ramus. Treatment consisted in simple rest in bed.

The fractures were found in young trainees, who previously had led a sedentary existence, and not in the older, conditioned soldiers.

Jones concludes that in the presence of pain in the adductor muscles, the hip or the pelvis a roentgenogram of the pelvis should be a part of the examination, and he believes that this injury would be found frequently in the armed forces if it were sought.

Hamilton and Finklestein⁴⁴⁹ report a case of march fracture involving the lower extremities of both fibulas. This is another addition to the voluminous recent literature on march fractures, describing them as occurring at practically any location where there can be unusual stress and strain on a bone. It is the authors' opinion that the condition is due entirely to overstrain.

March fractures are not rare but are reported under many other names, such as pseudofracture, wear and tear fracture, callous tumors and fractureless callus. Branch⁴⁵⁰ observes that in the first stage there is vague pain, usually diagnosed as of muscle origin. Roentgenograms may show no evidence of fracture at first, but they should be repeated every ten or fourteen days. In the second stage there may be circumscribed pain and pitting edema over the bone. Roentgenograms reveal

447 Brown, J. B. Surface Repair of Compound Injuries, *J. Bone & Joint Surg.* **26** 448-454 (July) 1944.

448 Jones, D. B. March Fracture of the Inferior Pubic Ramus, *Radiology* **41** 586-588 (Dec.) 1943.

449 Hamilton, A. S., and Finklestein, H. E. March Fracture. Report of Case Involving Both Fibulae, *J. Bone & Joint Surg.* **26** 146-147 (Jan.) 1944.

450 Branch, H. E. March Fractures of the Femur. *J. Bone & Joint Surg.* **26** 387-391 (April) 1944.

periosteal thickening and eventually densities and rarefaction in the bone structure Three cases of march fracture of the neck of the femur and 1 of the shaft are presented

Proctor, Campbell and Dobelle ⁴⁵¹ report 7 cases of march fracture of the tibia and 1 of the femur seen in a three month period at a station hospital The authors decry the tendency to misdiagnose these injuries as Garré's osteitis, periostitis, osteogenic sarcoma, bone syphilis and tuberculosis

The patients were found to be of the tall, fair, Nordic type, with an average age of 19 years and 8 months The mode of onset was sudden pain followed by lameness occurring during exercises Serum calcium levels were consistently low Treatment consisted in palliative physical therapy and cessation of rigorous activity Casts were not applied

Klass and Farrell ⁴⁵² report that fatigue fractures occur more often than they are recognized, that they cause callus formation that is often confused with tumor growth and that the treatment is simple and conservative

The authors report in detail on 8 fatigue fractures of the shaft of the tibia All followed arduous activity and were not recognized, as a rule, until two to eight weeks after onset of symptoms Vague aching pain and sharply localized tenderness were the most prominent symptoms Most of the fractures occurred at the junction of the middle and upper thirds of the tibia

The authors prefer the name "gradual fracture" for this condition since it more accurately describes the mode of occurrence Treatment usually consists in rest in bed for three weeks followed by wearing of an elastic bandage and light duty for four weeks

Ross ⁴⁵³ reports his use of the Stader splint at the Camp Borden Military Hospital on 28 patients His staff studied the use of the splint on cadavers for a week before adapting it clinically This probably accounts for the successful results obtained in this group of cases There were no deaths, no infections, 1 nonunion and better joint and muscle function "Pin seepage" and "ring sequestrums" were eliminated by use of a new type of pin, which could be drilled through the bone more easily It was also found that better control of fragments could be obtained if the pins were placed close to the fracture line Reimpaction of fragments at ten and at twenty days was found to be most important to prevent nonunion [ED NOTE—These surgeons have done better with the Stader splint than many surgeons]

⁴⁵¹ Proctor, S E, Campbell, T A, and Dobelle, M March Fractures of Tibia and Femur, Surg, Gynec & Obst **78** 415-418 (April) 1944

⁴⁵² Klass, A A, and Farrell W A Fatigue Fractures of the Tibia, J Canad M Serv **2** 25-36 (Nov) 1944

⁴⁵³ Ross, J W External Fixation in Fractures, Canad M A J **51** 543-546 (Dec) 1944

Shaar and Kreuz ⁴⁵⁴ report on 110 patients with fractures treated at the Philadelphia Naval Hospital with the Stader splint. Of these, 107 were returned to duty and 2 obtained nonunion. There were eleven fractures of the femur, forty-four fractures of the tibia and fibula, fourteen of the os calcis and ten of the humerus.

There was "pin seepage" in 10 per cent of the cases and only one frank infection about a pin. There was one instance of formation of a "ring sequestrum." There were two nonunions and 2 cases of undue bowing. [ED NOTE—The morbidity reported in this series is unusually low.]

Wenger ⁴⁵⁵ has devised two plates and four bolts of vitallium which can be placed across a fracture to provide secure immobilization. No external fixation or splint is required. [ED NOTE—This is much more stable than the usual single plate and screws. Nevertheless there is still danger of motion in a fracture of the shaft of the femur, no matter how secure the plate fixation. We have seen nonunion develop when two plates were applied, simply because motion could not be entirely prevented.]

Sava ⁴⁵⁶ describes a simple overhead wooden frame to be used for suspending an arm or leg while a cast is being applied. [ED NOTE—This resembles Magnuson's suggested small sawhorse for the same purpose. They are useful in the office or in hospitals.]

Lord and Coutts ⁴⁵⁷ report that the surgeons at the parachute school at Fort Benning have so improved methods of teaching that students now have less than a 1 per cent chance of being injured in a single jump.

In preliminary physical hardening, the most usual accident is tear of the right rectus abdominis muscle. This follows rope climbing and is often confused with the diagnosis of acute appendicitis.

In the tumbling training, acromioclavicular separation occurs if the landing is improper and the point of the shoulder strikes the ground.

In landing with the feet apart, fractures of the ankle often occurred. Now, however, with the improved method of landing, with the feet together, fractures more often occur in the upper end of the fibula.

454 Shaar, C. M., Kreuz, F. P., Jr., and Jones, D. T. End Results of Treatment of Fresh Fractures by the Use of the Stader Apparatus, *J. Bone & Joint Surg.* **26** 471-474 (July) 1944.

455 Wenger, H. L. Shaft Fracture Immobilization Without Plaster, *Am. J. Surg.* **66** 382-383 (Dec.) 1944.

456 Sava, A. F. An Aid in Casting of Fractures, *Am. J. Surg.* **66** 136-138 (Oct.) 1944.

457 Lord, C. D., and Coutts, J. W. A Study of Typical Parachute Injuries Occurring in 250,000 Jumps at the Parachute School, *J. Bone & Joint Surg.* **26** 547-557 (July) 1944.

All these injuries have been successfully combated by alterations in methods of teaching, so that parachute training is becoming increasingly safe

In military surgery Olson^{4 8} reports, tantalum has been used to make skull plates, ear frameworks and nerve sutures and to fill defects in jaws. The element tantalum was identified by Ekeberg in 1803, but the purified metal was extracted first by von Bolton in 1903 for light filaments. In 1936, Burch, Carney and Burke experimented with tantalum plates in laboratory animals. Their work led to its clinical use in the form of wires, plates and foil. [ED NOTE—This article gives elaborate descriptions of the metallurgic and chemical features of tantalum. It reveals the present uses of the metal in surgery. Bone plates and screws, however, have not been successfully produced from this element. Consequently, the Fracture Committee of the American College of Surgeons has declared that with present knowledge of the material, it is not suitable for plates and screws for use on long bones.]

XIV Conditions Involving the Spine and Thorax, Exclusive of Those in the Lower Part of the Back

PREPARED BY JOHN R. COBB, M.D. NEW YORK

THERE was a great decrease in the number of articles on conditions involving the spine and the thorax in the 1944 literature as compared with that of previous years, and only a few articles contain any real progress in orthopedic surgery.

Anatomic Variations—Walker⁴⁵⁰ present 3 cases of myelodysplasia associated with a dilatation of the spinal canal at the site of the anomaly and a case of vascular abnormality, angioma and aneurysm of the spinal cord accompanied with enlargement of the spinal canal at the site of the lesion. He discusses the roentgenographic and pathologic manifestations of myelodysplasia and points out that, although neoplastic conditions cause most instances of roentgenographically demonstrable enlargement of the spinal canal, congenital abnormalities of the spinal cord should be considered as etiologic factors.

He believes that enlargement of the spinal canal in these cases presumably occurred early in the development of the person, probably at the time the ossification centers were laid down. Since, except for the last case, there was no evidence of compression of the spinal cord either by lumbar puncture or at the time of operation—in fact, in the first 2 cases

⁴⁵⁸ Olson, C. T. Tantalum—A Glimpse of Its Surgical Future, *Indust Med* 13 738 (Sept.) 1944

of myelodysplasia there was much more room in the subarachnoid space than usual—if his assumption is correct it must then be assumed that the segments of the spinal cord did not change their position relative to the vertebral column, as normally occurs. At 3 months of intrauterine life, the segments of the spinal cord correspond anatomically to the vertebral segments, but normally at birth the lower end of the spinal cord lies at the third lumbar vertebra and in adult life at the first lumbar vertebra. In the lumbar region of the spinal cord, where most of the myelodysplasias occur, this lack of upward migration will cause considerable tension on the spinal cord, the main reason for symptoms developing early in adult life. The author states that although the enlargement of the spinal canal has been noted in some autopsies it has not been recognized generally by clinical neurologists or roentgenologists. He points out that in discussing the roentgenologic aspect of spina bifida occulta Dietrich does not refer to dilatation of the vertebral canal and that in Elsberg and Dike's paper on enlargement of the spinal canal no mention is made of myelodysplasia as a cause of such dilatation. Also Pancos, Pendegrast and Shaffer do not refer to it. He feels that, while it might be assumed that the dilatation of the canal associated with congenital anomalies could be distinguished from that due to intraspinal neoplasm by the appearance of the pedicles, in a case of enlargement due to congenital maldevelopment the pedicles might not be so eroded or thinned as in a case in which local pressure causes the dilatation, however, such a differentiation does not seem to be possible, for the pedicles are thinned in the present series of cases.

Cohn⁴⁰⁰ points out that congenital absence of a single rib is an infrequent occurrence and congenital aplasia of two or more consecutive ribs unilaterally is a rarity. Such a deformity may be present without other anomalies or is found more often in conjunction with defects of the pectoral muscle, of a vertebra or of the position of the scapula. He briefly reviews the literature on the reported cases of congenital absence of ribs. He believes that the association of aplasia of ribs with defect of the vertebral body is explainable on the basis of embryology and describes the development of the vertebral arch and the ribs. He concludes that the intimacy of the primordium of a rib and its corresponding vertebra is thus clearly shown from its embryologic standpoint. He feels that while Ritter and Eppinger believe that the defect of ribs is caused by the pressure of an arm against the thoracic

459 Walker A. E. Dilatation of the Vertebral Canal Associated with Congenital Anomalies of the Spinal Cord, *Am J Roentgenol* **52** 571-582 (Dec.) 1944

460 Cohn B. N. E. Congenital Absence of Ribs, *Am J Roentgenol* **52** 494-499 (Nov.) 1944

cage and although this hypothesis was favored by Thomson and Kienboch—the mechanical mechanism being considered because the arm could be placed in a hernial defect in the thoracic wall—it is impossible to conceive that an arm could remain in one position sufficiently long during intrauterine life to suppress the development of ribs either partially or totally. Moreover, the frequent association of rib defects with vertebral anomaly entirely vitiates this hypothesis. The theory of embryonic adhesions is, likewise, highly untenable.

Cohn reviews the studies of Stockard, who worked with the egg cells of killifish (*Fundulus*) and advanced an explanation for malformation. Stockard asserted that there are critical moments in the development of every organ or part which are characterized by a rapid cell multiplication. At such times, this particular proliferating lesion may exert a depressive influence over the growth of other parts. If this favorable moment of differentiation is not taken advantage of, the transient supremacy of the part is lost and it, in turn, submits to depression by other parts assuming their dominant period. The result is a reduced or an imperfectly formed region which, having lost this opportunity, is never able to express itself completely or perfectly in competition with other parts now arrived at similar states of preferment. Each organ or part, therefore, not only originates from a definite primordium but also arises at a definite moment that must be utilized by them if ever. According to Stockard's theory, the factor which operates most frequently in these defects is changes in the conditions, moisture, temperature and oxygen supply. Cohn feels that this theory appears to be the most tenable one for the explanation of aplasia of ribs and associated vertebral anomalies when present.

[ED NOTE—This is an interesting discussion of the problem of congenital absence of ribs, and the author gives a list of thirty-one references on the subject, although he does not go into the question of scoliosis or its relation to the absence of ribs.]

March⁴⁶¹ reports 2 cases of an apparently hitherto unreported vertebral anomaly, probably a persistent neurocentral synchondrosis, with some associated slight changes. In both of these cases the findings were incidental and had produced no symptoms, and in the two the same type of radiolucent line separating the upper left lateral corner of the body of the vertebra was noted. In both instances, the affected vertebra was associated with some abnormality of the intervertebral disk just beneath it. In discussing the interpretation of the appearance described in these 2 cases, March points out that it must be either an acquired defect, such as a fracture, or a developmental anomaly. He gives a brief consideration of the ossification of the vertebra and,

461 March, H. C. Vertebral Anomaly. Probable Persistent Neurocentral Synchondrosis, *Am J Roentgenol* 52:408-411 (Oct.) 1944.

while he admits that the fact that this radiolucent line runs diagonally caudad through the superior posterior-lateral aspect of the vertebral body instead of vertically through it is the chief objection to concluding that it represents a persistent ununited neurocentral synchondrosis, he believes that it is a developmental anomaly

Knutsson⁴⁶² presents an interesting study on variations in form and volume of the vertebral canal in lordosis and kyphosis and their significance in myelographic diagnosis. This is an excellent article with especially good reproductions of roentgenograms and anatomic drawings to illustrate the point brought out by the author. He shows by means of myelograms that in lordosis the narrowing of the vertebral canal has also caused a narrowing of the dural sack and that this narrowing decreases in kyphosis.

He found in lordosis a general narrowing of the vertebral canal on a level with the intervertebral spaces, principally of the fourth to the fifth lumbar spaces and the fifth lumbar space to the sacrum, was caused by increased protrusion of the intervertebral disk and the ligamentum flavum.

[ED NOTE—While this article was published in 1942, it was not reviewed previously under "Progress in Orthopedic Surgery." It seems worth mentioning, however, since it is of interest in the problem of protrusion of the intervertebral disk, that a flat back with a tendency to kyphosis is so frequently seen during the early stages and that later, when the disk has become completely sequestered, there may be a return to the normal lordosis and a loss of the previous flat back.]

Roentgenographic Technic—Cornwell,⁴⁶³ in an excellent article on roentgenographic technic for examination of the lumbosacral junction, describes the experimental roentgenologic technic in various angles and positions and discusses the anatomic and the technical considerations and the technic of examination. He gives complete charts of each technic for each position and examination of the patient from different angles. The reproductions of the roentgenograms are remarkably clear, showing excellent detail of the bone, and the photographs are most satisfactory, illustrating the various positions for examination of the lumbosacral area.

[ED NOTE—While much of the material in this article has been discussed in previous articles, it is an excellent reference, covering the subject well, and is worth reviewing by many orthopedic surgeons,

462 Knutsson, F. Variations in Form and Volume of Vertebral Canal in Lordosis and Kyphosis. Significance in Myelographic Diagnosis, *Acta radiol* 23 431-443, 1942

463 Cornwell, W. S. Lumbosacral Junction, *Radiog & Clin Photog* (no 3) 19 58-69, 1943

roentgenologists and technicians who are interested in the roentgen ray study of the lumbosacral area]

Ankylosing Spondylitis—Fletcher⁴⁶⁴ states that the incidence of ankylosing spondylitis, once considered a rare disease, appears to be increasing and a good many cases are seen in the armed services. He reports 68 cases which he includes in the general group of von Bechterew, Strumpell and Pierre Marie, excluding the other cases of spondylitis, due to specific types of organism and osteoarthritis of the spine, which he feels is more correctly termed "spondylosis."

In this group of 36 men 21 had sedentary occupations while 15, including 5 soldiers, did manual work. Of the 32 women, 13 were housewives, 7 domestic workers, 3 nurses and 9 office workers. The average age at the time of diagnosis was 38.4 years for men, and 40 for women. In the cases of the men, the average time between the onset of symptoms and the time of diagnosis was 2.9 years and in the cases of women 2.5 years.

Fletcher divided the patients into two groups: those with symptoms for less than a year (23) and those with symptoms for more than a year (28). The author also concludes that there is a far greater incidence of the disease in the lumbar portion of the spine in young men. He points out that most reports have stated that this disease is predominantly in men, however, in this series there were 32 women. The author feels that the disease, as seen today, includes features of both the older types, of von Bechterew and Marie-Strumpell, and it is uncertain why such clinical observers should have described only cases of one kind or the other.

In his roentgenographic studies, Fletcher includes the cases of only 65 patients, as 3 patients did not have adequate roentgenologic check-up. He divides them into four groups: (a) sacral focus only (17 cases), (b) sacral focus and involvement of spine (10 cases), and (c) ankylosed sacroiliac joint and involvement of spine (30 cases).

He found no significant variations in sex distribution, sedimentation rate, age, length of history, treatment or prognosis among these groups. He also feels that the erythrocyte sedimentation rate is not of great value in prognosis. Some patients do well in spite of a rising value and vice versa. An erythrocyte sedimentation rate of 15 mm an hour being taken as raised, 27 of the 36 men and 17 of the 32 women had a raised rate. If 10 mm an hour is taken as the top limit of normality, 33 of the 36 men and 22 of the 32 women showed a high erythrocyte sedimentation rate.

He classified 8 of the cases in a separate group, in which the disease clinically resembled ankylosing spondylitis with a sacral focus.

464 Fletcher, E. Ankylosing Spondylitis, *Lancet* 1 754-756 (June 10) 1944

In this group, the average age at the onset of symptoms was 43 and at diagnosis 46. In 5 cases the onset was in the 40 to 50 age group. There were 5 women and 3 men, the site of the attack in all the women was in the cervical area and in 3 men in the dorsal region.

The author points out that it is hard to estimate the value of treatment in a condition subject to remission, but certain measures are clearly beneficial. He feels that roentgen ray treatment cures some patients, the Kromayer lamp has a favorable effect in most cases, gold compounds have apparently been of use, the plaster bed is helpful, and physical methods play an important part in all cases, especially those in which there is diminished respiratory excursion. He does not mention the use of support, such as back braces.

[ED NOTE—This is an interesting paper, but the author does not go into much detail on the matter of treatment and does not discuss the use of braces, the importance of prevention of deformity or the more recent use of osteotomy of the spine for correction of very severe deformities. It is also noted that he does not point out, as other authors have done, that the roentgen ray treatment is primarily for the relief of pain and is of value mainly in the early stages.]

Scoliosis—Bickel, Hinchey and Clagett⁴⁶⁵ report the treatment of 10 patients with severe scoliosis by means of rib resection and immediate fusion of the spine. They state

In treatment of scoliosis the primary consideration of the orthopedic surgeon is the arrest of the progress of the spinal curvature. In some cases of thoracic scoliosis a secondary problem presents itself, namely the cosmetic deformity of the back.

In the last twelve years the procedure of rib resection with use of the removed segments of ribs to fuse the vertebrae has been performed in ten cases at the Clinic.

The procedure is described as follows:

The patient is first placed under 6 pounds (27 Kg.) of traction to the head and feet on a curved hyperextension frame for seven to ten days. The apex of the traction corresponds to the point of greatest convexity of the spinal curve. Rib resection and spinal fusion then are done as one procedure, the former by a thoracic surgeon and the latter by an orthopedic surgeon. The two previously discuss and agree on both the number and extent of ribs to be resected and the number of vertebrae to be fused. The entire procedure can be carried out through one long incision over the spinal column but more frequently two incisions are used, one over the convexity of the ribs and a parallel straight incision exposing the vertebrae to be fused. The ribs are resected subperiosteally throughout the extent of the prominence. The resected portions are split lengthwise and placed along the concave side of the spinal curve next to denuded laminae and spinous processes, their own curve frequently corresponds to that of their spinal bed and they may be broken in a green-stick fracture for even closer coaptation.

⁴⁶⁵ Bickel W. H., Hinchey, J. J., and Clagett O. T. Treatment of Severe Scoliosis with Rib Resection and Immediate Fusion of Vertebrae, Proc Staff Meet Mayo Clin 19 401-424 (Aug 9) 1944.

They are placed in an overlapping double row throughout the extent of the curve and held in place by closure of the overlying muscles and fascia. There is always more than enough bone for use as grafts. Following operation the patient is placed for two weeks on a straight Bradford frame and is turned from the prone to supine position and vice versa at regular intervals. The use of the previously mentioned traction and hyperextension frame is resumed for four weeks. At the end of this period a plaster body jacket is supplied with the patient on a Goldthwaite frame. The patient is permitted to be up and around for a week, the cast then is removed and another which extends from the occiput and chin to include the iliac crests is applied with the patient in upright suspension. This cast is worn for four months after which it is replaced by a corset or brace which is worn for six months. At the end of this six months such activities as swimming and breathing exercises are started and the corset or brace is discarded gradually, there is then a progressive return to normal activity.

Bickel and his colleagues report that in 3 cases the operations were complicated by pleural effusions. No other complication occurred in this series, nor was there a fatality. The patients withstood a rather extensive operation well. If after the resection of the ribs further operation is not thought advisable, the ribs can be preserved by refrigeration and used at a subsequent operation for grafting of the spinal column.

The authors state that roentgenograms of the ribs six months after the operation showed remarkable osseous regeneration from the periosteum of the resected ribs, this regeneration conformed to the new contour of the thoracic wall. Clinically, the thoracic cage was rigid after about six months.

[ED NOTE—Since many surgeons are attempting major operations on patients with scoliosis and since Bickel believes that in selected cases, in which the deformity of the thoracic cage is severe enough to warrant it, rib resection with immediate use of the ribs to secure spinal fusion is the procedure of choice, it seems desirable to consider a few points in this problem.

First, 10 cases (really only 7 cases followed beyond six months) are not sufficient for satisfactory conclusions, and so few cases have been reported in the literature that the value of the procedure is still debatable.

Second, most of the patients were evidently beyond the age of 15, the average age being 16, and, since only 1 case was due to poliomyelitis, the disease in these patients had apparently already stopped progressing and the curves would not have increased if they had not been fused. As idiopathic scoliosis rarely increases in girls after the age of 15 and in boys after 16, one has little proof that this procedure really stopped the progress of the curve in these cases, the scoliosis in 2 actually increased.

Third, since in 2 of the 7 cases the curve increased and in the others remained stationary or improved only slightly, no significant improvement in the curve can be expected from this procedure

Fourth, it would seem, therefore, that the only improvement to be obtained from this procedure is a decrease in the prominent angulation of the ribs on the convex side of the curve or razorback deformity and that the success of the procedure is difficult to evaluate. In the discussion Bickel states that "since the majority of these patients are adolescent girls, the most frequent complaint when they are seen is the developing deformity" and "if the deformity can be corrected to some extent and the scoliosis arrested by spinal fusion in the same procedure without undue risk to the patient, I can see no objection to this type of surgical procedure," and "in selected cases in which the deformity of the thoracic cage is severe enough to warrant it, I believe that rib resection with immediate use of the ribs to secure spinal fusion is the procedure of choice." These statements tend to encourage the inexperienced orthopedic surgeon to use this procedure for adolescent girls with increasing curvatures. While it is possible that this procedure might be considered in certain cases in which the angulation of the ribs was already severe and in which the curve was increasing rapidly and a decrease in the prominence of the ribs and the arrest of the progress could be expected following a solid fusion, most orthopedic surgeons who have had considerable experience in the correction and fusion of idiopathic scoliosis feel that such pronounced improvement in the curve can be obtained by correction and fusion if done early enough, they feel that usually the rib resection is not indicated or that if it is it should be done only after the maximum correction of the curve is obtained and secured by a solid fusion of the spine in adolescent patients whose curvatures are increasing.

Fifth, it should be noted that resection of ribs, being a thoracoplasty procedure, tends to produce a curve convex to the same side, so that in the younger patients especially one would be adding a factor of possible increase in the curve if the ribs on the convex side are resected and the spinal fusion is not sufficiently solid. Patients with severe scoliosis usually have considerable decrease in the vital capacity and unless there is little or no pulmonary tissue under the severely angulated ribs of a razorback area, some further decrease in the vital capacity should be expected after the ribs in that area have been resected. Is this desirable in a patient who already has decreased vital capacity as a price for uncertain cosmetic improvement? One must also consider how much cosmetic improvement could be expected from the removal of only three to six ribs, as in most cases of severe scoliosis more than six ribs are involved and the prominence of the transverse processes and the severe rotation make it impossible to obtain a satis-

factory correction In several of our cases, extensive rib resection long after a solid fusion of the spine was obtained did not result in sufficient further improvement to warrant the procedure in our opinion

Sixth, if there is any indication for this procedure it would seem to be in a case of scoliosis in which little if any correction could be expected, usually in scoliosis not progressing and too old or rigid to get correction and in a patient for whom one wanted only to decrease the prominence of the ribs and at the same time stabilize the spine and prevent any tendency of the curve to increase after the rib resection

The indications for the procedure would therefore seem to be exceedingly rare and when present should have the careful consideration of one experienced in the problem of scoliosis before being attempted]

Pleurodynia—Kelly⁴⁶⁶ reviews the literature and discusses the problem of pleurodynia and intramuscular fibrositis and the use of local anesthesia as an aid in the study and the treatment of patients with pain in the chest He refers to the opinions of Stockton, Ray, Lewis and Kellgren and others in earlier reports and discusses the mechanism of thoracic pain and the rationale of its treatment He feels that observations suggest that somatic and visceral lesions may be linked in an association more intimate than is generally suspected and believes that it is likely that the muscles will prove to play a large part in the mechanism of the production of the spontaneous pain of disease The author believes that the essence of pleurodynia is a painful lesion of the muscles surrounded by a fibrositic reaction and that in the majority of cases a cure will result from the infiltration of the lesion with a local anesthetic agent He also believes that when pain in the chest is associated with physical kinds of disease of the lungs or the pleura, the pain can often be relieved in the same fashion He reports successful results in 35 cases He gives 9 case reports to illustrate various points, 1 especially to disprove the common belief that the pain of dry pleurisy is due to the rubbing together of two surfaces roughened by fibrous exudates, for in this case the pain was relieved by 1 cc of local anesthetic injected into the tender spot, although the friction rub of the pleurisy continued for three days

Lesions of Disks—Downing⁴⁶⁷ states that while several cases have been reported of injury to the intervertebral disk by lumbar puncture followed by persistent pain in the back and roentgenologic evidence of collapse of the disk, the direct relationship still remains in dispute He reviews the literature and points out that in 1919 Levinson stated

466 Kelly, M Pain in the Chest Observations on the Use of Local Anaesthesia in Its Investigation and Treatment, M J Australia 1 4-7 (Jan 1) 1944

467 Downing, F H Collapse of Intervertebral Disc Following Spinal Puncture, U S Nav M Bull 43 666-673 (Oct.) 1944

that the spinal puncture needle if inserted too far might dislodge the ligament from the nuclear material, which would account for failure to obtain spinal fluid. Pease, doing experimental lumbar punctures on cadavers, found that it was not always possible to determine when the point of the needle entered the neural canal, passed it or entered the intervertebral disk. Munro and Harding, in reviewing the needle technic in myelography, allowed the needle to remain in place while lateral roentgenograms of the spine were made. They found that of the sixty needles inserted, 36 per cent were in such position that had they been inserted farther in their course they would have penetrated the annulus fibrosus. The average distance between the point of the needle and the annulus was from 4 to 5 mm. Pease also demonstrated that when the torso is flexed in preparation for a lumbar puncture and the needle is inserted in the midline beyond the neural canal it will enter the intervertebral disk, if the body is not flexed, the needle will strike the vertebral body or enter the venous sinusoid or one of the connecting veins. Flexion of the spine increases the intervertebral disk pressure, and, because of the stronger anterior elements of the disk, this pressure is reflected in the weaker or the posterior portion, causing a slight bulging of the disk into the neural canal. The needle, in entering the disk allows the nuclear material to escape into the lumen or around the needle.

Experimental studies by Keyes and Compere led them to conclude that a minor puncture of the intervertebral disk might result in the escape of the nuclear material, pain in the back and disability, partial collapse of the disk and marginal proliferation of the adjacent vertebral bodies. In discussing the mechanism of the injury, Downing mentions that the posterior longitudinal ligament in the lumbar segments becomes narrowed and thus only reinforces the annulus fibrosus in the posterior portion of a small area. He is of the opinion that when the needle point becomes deflected to either side of the midline it may be deflected past the dura without penetrating it and the operator, not obtaining the spinal fluid, continues to advance the needle until finally the annulus fibrosus and the intervertebral disk are penetrated lateral to the posterior longitudinal ligaments. If this is repeated, several punctures of the annulus will occur in this area, the damage may be sufficient to allow the subsequent escape of nuclear material or to precipitate traumatic degenerative changes which finally result in collapse of the intervertebral disk. In the first case reported here the onset of early symptoms together with long delayed evidence of collapse of the intervertebral disk would indicate that the pain was more likely due to extensive trauma to the disk rather than to the subsequent escape of nuclear substance. Resultant collapse of the disk was purely a later degenera-

tive reaction precipitated by the original trauma, it was also manifested by productive osteoarthritic changes

In both cases reported here conservative treatment was tried, but apparently the patients were still complaining, and spinal fusion was considered. Roentgenograms from these 2 cases were presented showing no narrowing of the intervertebral disks previous to lumbar puncture and, later, a definite narrowing of the disk involved.

Downing believes that the acutely flexed position of the spine when the puncture is made increases the danger of injury to the disk by increasing the intradisk pressure and directing the needle toward the intervertebral space. The needle should be angulated cephalad so that in case it is inserted too deeply it will strike the posterior surface of the superior vertebra. He suggests the use of a sharp fine caliber short bevel needle and extremely careful technic.

[ED NOTE—While numerous cases of collapse of the intervertebral disk following spinal puncture have been reported, this paper presents anatomic considerations and suggestions for avoiding this occurrence. It seems worth while to stress the increasing number of cases of injury to the intervertebral disk following lumbar puncture and to suggest more caution in this procedure.]

Spurling and Scoville⁴⁶⁸ (reviewed by Dr R. Beverly Raney, Durham, N. C.) call attention to the role of the lower cervical intervertebral disk in the production of pain in the shoulder and arm. They review the literature and point out that most reports on ruptures of cervical intervertebral disks have indicated that the lesion is likely to be confused with neoplasms of the cervical portion of the cord. The anatomy of the cervical part of the spine and the spinal cord in this area is discussed. The pathologic changes are described, and the causation is pointed out. A brief description of the symptoms is given. Pain and stiffness of the neck are usually the first symptoms, and generally any sudden movements of the head and neck will produce a feeling of electrical shock in the arm and hand of the involved side. Numbness and tingling may be present. Tenderness to fist percussion at the site of the lesion is a fairly constant observation. They state that the most important diagnostic test which is almost pathognomonic of a cervical intraspinal lesion is the neck compression test, in which the head and neck are tilted toward the painful side and pressure exerted on top of the head, when this test intensifies the pain, the reaction is considered to be positive. In the differential diagnosis the authors mention neoplasms, inflammation of nerves, scalenus anticus syndrome, cervical ribs and bony spur formation in the intervertebral foramina.

468 Spurling, R. G., and Scoville, W. B. Lateral Rupture of Cervical Intervertebral Discs. Common Cause of Shoulder and Arm Pain, *Surg., Gynec. & Obst.* 78: 350-358 (April) 1944.

Roentgenograms may show narrowing of the intervertebral space, with loss of the normal lordotic curve. The authors report the cases of 12 patients who had been operated on for ruptured cervical intervertebral disks. All the patients were relieved of radicular pain within two weeks following operation. Spurling and Scoville recommend that during the postoperative period the patient be kept recumbent as long as there is residual pain in the upper extremities or shoulders.

Brooke⁴⁶⁹ (reviewed by Dr R. Beverly Raney, Durham, N. C.) presents a detailed report of a case of complete transverse cervical myelitis caused by traumatic herniation of an ossified nucleus pulposus. The patient was admitted to the hospital with complete flaccid paralysis below the fifth cervical segment and with loss of sensation of all types below the sixth cervical segment. Death occurred fifteen days after admission. Autopsy showed a defective and frayed posterior longitudinal ligament, with posterior protrusion of a calcified nucleus pulposus between the fourth and fifth cervical vertebrae. The cord at this level presented a transverse depression with softening. It was believed that the symptoms were initiated by trauma, resulting in degenerative changes in the intervertebral disk.

Multiple Intraspinal Lesions—Ehni⁴⁷⁰ reports a case of multiple intraspinal lesions in which part of the clinical picture was caused by a neurofibroma at the level of the conus medullaris and the rest, including the chief complaint, pain, was caused by a protrusion of the fourth intervertebral disk. Myelography demonstrated the existence of the two lesions and made clear a problem that might otherwise have led to an imperfect solution and result.

He reminds the reader that intraspinal tumors, with the exception of protrusions of intervertebral disks, are rather uncommon lesions (the incidence has been 1 in 2,000 registrants at the clinic) and instances of multiple intraspinal tumors are positively rare. There are two diseases in which multiple intraspinal lesions are the rule. One of these, von Recklinghausen's disease, presents multiple neurofibromas of intraspinal nerve roots, together with multiple meningiomas. Syringomyelia is the other disease, but in addition to the syrinx a tumor of the blood vessel is often present. Protrusions of disks are also multiple in a certain percentage of cases. Aside from these conditions, the author was able to find but 3 instances of multiple primary intraspinal lesions in the records of the clinic, although he has no doubt that there are others. In 1 of these cases, the patient had spastic paraparesis. A myelogram with radiopaque oil revealed complete obstruction to the

469 Brooke, W. S. Complete Transverse Cervical Myelitis by Traumatic Herniation of Ossified Nucleus Pulposus, *J. A. M. A.* **125** 117-120 (May 13) 1944.

470 Ehni, G. J. Multiple Intraspinal Lesions. Report of Case, *Proc. Staff Meet., Mayo Clin.* **19** 489-491 (Oct. 4) 1944.

upward passage of the oil at the tenth thoracic vertebra due to what subsequently proved to be a meningioma. However, in addition, there were multiple protrusions of the intervertebral disk. Removal of the tumor and decompression of the protruded eleventh thoracic disk by laminectomy resulted in complete recovery. The second patient underwent removal of a meningioma from the region of the foramen magnum and returned three years later for removal of a thoracic meningioma. The third patient was operated on for removal of a protruded disk, but when the nerve root was exposed there seemed to be a swelling on it the size of a pigeon egg which proved to be a neurofibroma. In addition to this tumor, there was a protrusion of the underlying disk. Removal of both lesions resulted in relief of all symptoms.

Ehni points out that the danger of attributing a patient's symptoms to a protrusion of a disk when in reality they are due to an unsuspected intraspinal neoplasm is a real one. Usually it is the tumor that is harder to recognize because the threshold of suspicion is much lower for protruded disks than for intraspinal tumors. In the case he reports there were multiple intraspinal lesions, with a new twist to the problem in that the neoplasm was much in evidence while the protruded disk was less so. He states that the patient had a From syndrome, complete manometric block, clinical evidence of a conus lesion and roentgenographic confirmation of the level. The decision to perform myelography was reached because of the nature of the pain. It had been in both legs and subsequently confined itself to the left. This occurrence Ehni believes to be more characteristic of a protrusion of a disk than of a steadily augmentive mass, such as a neoplasm. After a tumor had been removed and the evidence of stricturing of the caudal sac during passage of the catheter was added to the myelographic evidence of a second lesion, the question arose whether or not to remove the two lesions at the same time. It was known that the second lesion existed, but it was not known that the lesion was causing symptoms. It was decided that the safest course would be to postpone its removal until after it was determined that removal was necessary. After a few days it became evident that removal was necessary, and the patient was relieved completely after the second operation.

[*ED NOTE*—While the use of an intraspinal contrast medium in cases of suspected disk lesions is still disputed, the possibility of more than one lesion is certainly an argument in favor of it. However, some cases are so typical without much doubt as to the presence of a disk that many surgeons still feel that in these cases exploration for disk lesions should be performed without the use of opaque material, while other cases are sufficiently doubtful to warrant its use.]

Aneurysmal Bone Cyst of the Spine—Mayer and Kestler⁴⁷¹ report 2 cases of aneurysmal bone cyst of the spine. In the first case the cyst was located in the body of the seventh dorsal vertebra, and in the second case it was in the second dorsal vertebra. In both cases treatment consisted in laminectomy and curetting of the tumor, and the diagnosis was confirmed by microscopic examination. There was improvement in both cases following these operations, although in the second case there were the complications of decubitus ulcers and flexion contractures of the hips and knees. The authors point out that benign neoplasms of the vertebrae large enough to produce extensive neurologic symptoms are extremely rare and regression of such symptoms following operation is still more infrequent. They feel that the recovery in these 2 cases following operation for aneurysmal bone cyst of the vertebrae indicated that, despite the extensive neurologic evidence of damage to the cord, remarkable improvement is possible following operation.

Adolescent Kyphosis—MacGowan⁴⁷² reviews and summarizes the anatomy and physiology of the spine in a paper on adolescent kyphosis. He discusses the mechanics of kyphosis, and he thinks that in every case of adolescent kyphosis the vertebral nucleus is destroyed before the ossification of the vertebral body is complete. This destruction may be caused by failure of the cartilaginous disk to retain a nucleus or by softening of the vertebral body, which allows the nuclear tissues to prolapse into soft vertebral bodies. As soon as this happens, the weight-bearing function is transferred to the bodies anteriorly and the axis of motion to the posterior vertebral elements, increased pressure results at the anterior borders of the vertebral bodies when the spine is in flexion. If the patient is adolescent, the epiphysis will be subject to trauma. Abnormal ossification follows, leaving after a period of increased growth a premature closure of the epiphysis, failure of anterior vertebral ossification and wedged formation of the vertebral bodies.

The author describes three different types: mobile kyphosis, fixed kyphosis and fixed arthritic kyphosis, the mobile stage being the earliest and merging after a variable period into the fixed and fixed arthritic stages. He believes that the tightening of the posterior thigh muscles and the shortening of the hamstrings contributes to the formation of kyphosis and when the back is flexed, as in toe-touching exercises, damage to the dorsal portion of the spine may result. Of 62 cases, tight hamstrings were present in 66 per cent of the mobile type and

471 Mayer, L., and Kestler, O. C. Aneurysmal Bone Cyst of Spine, *Bull Hosp Joint Dis* 5:16-22 (April) 1944

472 MacGowan, T. J. B. A. Adolescent Kyphosis, *Lancet* 1:211-214 (Feb 12) 1944

in 70 per cent of the rigid type. A secondary scoliosis was found in 27.2 per cent of his cases. The author made studies on the blood of several representative patients with the various types and reports no gross deviation from the normal in the organic or the inorganic elements of the serum or corpuscles.

[ED. NOTE—Only 4 cases are reported which include these hematologic studies and these are hardly enough to conclude that all cases are normal. The author differs with other writers, who report the disease almost entirely in boys, reporting the occurrence of kyphosis in 64 boys and 66 girls. He classifies these cases of kyphosis in five groups on an etiologic basis (asthmatic, endocrine, congenital, apprentice and traumatic), and he illustrates the roentgenologic appearance of the normal spine and the kyphotic spine at various ages.]

(To Be Continued)

ABDOMINOPELVIC SYMPATHECTOMY FOR RELIEF OF PAIN OF CANCER OF THE CERVIX

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SEVERAL physicians have tried to relieve the pain of cancer of the uterus by surgical intervention on the sympathetic system. It is to be noted that Jaboulay¹ in 1899 had attempted to relieve pelvic pain by interrupting the afferent pathways in the sacral sympathetic chains. Ruggi² in the same year advised resection of the utero-ovarian plexus. These procedures were not immediately followed by other surgeons.

Later, in 1921, Leriche³ introduced periarterial sympathectomy of the hypogastric arteries, and Cotte⁴ in 1925 showed that pelvic pain may be relieved by interruption of the hypogastric plexus. In the same year Leriche⁵ suggested periaortic and peri-iliac sympathectomy for relief of pain due to inoperable neoplasms in the pelvis. It was especially after the investigations of these authors that abdominopelvic sympathectomy was performed with the purpose of relieving the pain of patients with inoperable cancer of the uterus.

In 1932 Fontaine and Herrmann⁶ published the results obtained with sympathectomies in the treatment of pain of carcinoma of the cervix uteri in 6 patients operated on by Leriche. The first patient had

1 Jaboulay, M. Le traitement de la nevralgie pelvienne par la paralysie du sympathique sacre, *Lyon méd* **90** 102, 1899.

2 Ruggi, G. Della simpatectomia al collo ed all'adome, *Polislinico* **6** 193, 1899.

3 Leriche, R. Essai de traitement du kraurosis vulvae par la sympathectomie de l'artère hypogastrique, *Bull et mem Soc de chir de Paris* **47** 1150, 1921, *Resultats de la sympathectomie faite sur les artères hypogastriques et ovariennes en gynécologie*, *Presse méd* **33** 465, 1925.

4 Cotte, G. La sympathectomie hypogastrique a-t-elle sa place dans la thérapeutique gynécologique? *Presse med* **33** 98, 1925. Cotte, G., and de Chaume, M. Technique et indications opératoires des interventions sur le sympathique pelvien (sympathectomie periarterielle hypogastrique, section du nerf presacre) en gynécologie, *J de chir* **25** 653, 1925.

5 Leriche, R. Sedation a l'aide de la sympathectomie periaortique et peri-iliacque des douleurs provoquées par les cancers abdominaux inoperables, *Lyon chir* **22** 701, 1925.

6 Fontaine, R., and Herrmann, L. G. Clinical and Experimental Basis for Surgery of the Pelvic Sympathetic Nerves in Gynecology, *Surg, Gynec & Obst* **54** 133, 1932.

intractable pain in the pelvis and right leg, associated with an inoperable carcinoma. The hypogastric plexus was resected, and periarterial sympathectomy was done on both the common iliac arteries. The pain was greatly relieved by this operation, the patient complained only of an occasional dull pain in the pelvis. She gradually became worse and died nineteen days after operation.

The second patient with cancer of the cervix uteri had a pronounced burning sensation in the pelvis, associated with cramplike pain that radiated to both thighs. Extensive resection of the hypogastric plexus was done, the lower lumbar and the upper sacral sympathetic chains were removed, and complete periarterial sympathectomy of the internal iliac arteries was carried out. After the operation the pain disappeared completely, slight tenesmus of the vesical and rectal sphincters remained. She was completely relieved of pain until her death eight months later.

The third patient complained of severe pain in her right leg, associated with great edema of that member. A limited resection of the hypogastric plexus was done, this operation had no influence on the edema and did not relieve the pain in the thigh.

The fourth patient with inoperable cancer of the cervix uteri had sharp, severe pain in the pelvis radiating down both thighs. The hypogastric plexus was resected, and both lumbar sympathetic chains were sectioned at the level of the fifth lumbar sympathetic ganglion. After the operation, the pain in the thighs and pelvis disappeared completely. The later course of this case was not known.

In the fifth patient, there was excruciating pain in both thighs and in the left leg, some time later, phlebitis of the left leg developed and severe pain began in that leg. The preaortic plexus was removed, the inferior mesenteric nerve was sectioned at the level of the fourth lumbar vertebra, the left lumbar sympathetic chain was resected for about 1 inch (2.5 cm) and the right fourth lumbar sympathetic ganglion was resected. This operation entirely relieved the patient of all her symptoms. Until her death six months later, she did not complain of pain or discomfort.

Finally, the sixth patient complained of constant pain in the pelvis, with lancinating pain radiating down the anterior surface of the right thigh. The preaortic and the hypogastric plexus were resected. The right lumbar sympathetic chain was sectioned just above the level of the fourth lumbar sympathetic ganglion. After this operation the patient was completely relieved of all pelvic pain and for five months remained without pain.

Leriche⁷ has added to the iliac and aortic periarterial sympathectomies for the treatment of pain in cancer of the uterus, resection of

⁷ Leriche, R. *Surgery of Pain*, translated by A. Young, London, Baillière, Tindall & Co., 1939, p. 459.

the presacral, sometimes also of the inferior mesenteric plexus and often of a portion of the two lumbar ganglionic chains Leriche and Fontaine have operated in this way on 9 patients with inoperable cancer of the uterus Six of these patients were followed for two to eight months They were relieved completely from their pain, and they died without having recurrence of pain

In 10 patients with intractable pain from carcinoma of the cervix uteri, Greenhill⁸ in 1933 obtained complete relief from pain in all cases by sympathectomy In the same year Wetherell⁹ reported that 2 patients were relieved of pain by the same procedure

In 1935 Atlee¹⁰ performed presacral sympathectomy for pelvic pain in 3 cases of carcinoma of the cervix uteri In 1 case the patient had severe pain in the left side of the abdomen and down the left leg, with sacralgia This patient seemed to have relief following the operation, but after she returned home the pain became as severe as ever The second patient had severe pain in the left side and back following treatment with radium, with evidence of extension in the left obturator region This patient estimated that she had obtained about 60 per cent relief The third patient had severe pain in both iliac regions and in the back following radium treatment, with evidence of extension of the growth along both sacroiliac ligaments After sympathectomy, the abdominal pain was relieved but considerable rectal pain persisted

Fulcher¹¹ in 1938 performed presacral sympathectomy on a patient suffering with pelvic pain following radium treatment and on 1 suffering with inoperable carcinoma of the cervix and body of the uterus, with complete relief of pain in each instance

In the same year (1938) Cutler,¹² analyzing the surgical treatment of pain, stated that removal of the presacral nerve and associated fibers, with or without periarterial sympathectomy of the iliac arteries, had been carried out in an attempt to relieve the pain of inoperable cancer and chronic painful infection in the pelvic viscera He said that this operation had been loudly acclaimed by many gynecologists but in his hands had not given more than 50 per cent of good results

Verbrugghen¹³ (1940) stated that in intractable pain due to carcinoma confined to the body of the uterus relief may be obtained by

8. Greenhill, J P, in discussion on Wetherell,⁹ p 1299

9 Wetherell, F S Relief of Pelvic Pain by Sympathetic Neurectomy Report of Seven Cases in Which the Superior Hypogastric Plexus (Presacral Nerve) Was Resected, J A M A **101** 1295 (Oct. 21) 1933

10 Atlee, H B Presacral Sympathectomy for Pelvic Pain, Canad M A J **32** 54, 1935

11 Fulcher, O H Sympathectomy for Control of Pain, M Ann District of Columbia **7** 89, 1938

12 Cutler, E C The Surgical Treatment of Pain, New England J Med **218** 422, 1938

presacral sympathectomy As soon as the carcinoma invades the cervix and the supporting fascial ligaments which are supplied by somatic nerves, presacral sympathectomy can produce little effect and recourse must be had to chordotomy In 2 cases he had seen relief for about six months and nine months follow presacral sympathectomy for pain caused by carcinoma of the body of the uterus

According to Greenhill¹⁴ (1941) the most difficult group of patients to relieve of pain are those who suffer from cancer of the pelvic organs He stated that in cases of malignant growths in the pelvis, sympathectomy will yield almost perfect results if it is restricted to patients who have pain in the middle of the lower part of the abdomen, pain low in the back, rectal tenesmus, pain in the bladder and pain associated with vesicovaginal and rectovaginal fistulas

The aforementioned investigations demonstrate the possibility of relieving pain in certain cases of cancer of the cervix uteri by sympathetic operations However, when abdominopelvic sympathectomy is performed at the same time that pain is relieved by interruption of the afferent sensory pathways, the efferent fibers are also interrupted and vasodilatation is induced at the level of the uterus and of the tumor I have tried in these investigations to ascertain what is the influence on the development of the tumor of the disturbance of blood supply caused by ligation of both hypogastric arteries followed by abdominopelvic sympathectomy In connection with this problem, Cutler and Buschke¹⁵ (1938) stated that it is often assumed that the ligation of the lingual or the uterine artery diminishes the vitality of a tumor which it supplies and that ligation thus makes the tumor more vulnerable to radiation therapy The contrary, however, is true This relationship also has a most important bearing on the value of the postoperative irradiation and, in a large measure, may explain the failure of irradiation in sterilizing postoperative recurrent disease which arises in a poorly vascularized scar tissue

To clarify this problem and to avoid danger of hemorrhage at the level of the ulcerated cancer of the cervix following sympathectomy, I have ligated the hypogastric arteries whenever abdominopelvic sympathectomy was performed I have carried out a series of investigations in patients with cancer of the cervix uteri, put at my disposal by Prof F Gentil In these patients I performed abdominopelvic sympathectomy and bilateral ligation of the hypogastric arteries The blood supply

13 Verbrugghen, A The Treatment of Intractable Pain, *Internat Clin* 2 148 1940

14 Greenhill, J P Control of Pain in Cases of Cancer, *M Clin North America* 25 117, 1941

15 Cutler, M, and Buschke, F Cancer Its Diagnosis and Treatment, Philadelphia, W B Saunders Company, 1938

of the uterus was only partially diminished by the ligation of the hypogastric arteries, because a collateral arterial circulation develops. Moreover, this collateral circulation is increased by the abdominopelvic sympathectomy¹⁶. Different types of abdominopelvic sympathectomy were performed in order to determine their comparative values in the treatment of pain in inoperable cancer of the cervix uteri. I have also attempted to determine whether abdominopelvic sympathectomy must or must not be followed by adequate physical therapy (radium and roentgen rays).

PAIN IN CANCER OF THE CERVIX UTERI,
MECHANISM AND PATHWAYS

Carcinoma of the cervix uteri generally progresses for a long time without pain, however, in a later phase of growth of the neoplasm, when the adjacent structures of the pelvis have been involved (Cutler and Buschke¹⁵), pain may occur and may be the dominant symptom. In certain cases the patient suffers so intensely that special treatment is necessary to relieve the intolerable pain.

Among the different methods of treatment known today, the relief of visceral pain by sympathectomy has been suggested and performed in recent years.

It must be remembered that of the three types of pain (localized and fixed prevertebral pain, spinal pain and diffuse pelvic and abdominal pain) which may be observed in cases of cancer of the cervix uteri (Leriche⁷), only the diffuse pelvic and abdominal pain is related to sympathetic innervation and is relieved by sympathectomy.

In cancer of the cervix uteri, in the beginning the pain localized in the pelvis usually does not have a definite distribution. It may be a vague painful sensation in the lower part of the abdomen, in the lower part of the back or in the perineum, radiating to the thighs on one or both sides. It is a visceral pain in the field of the sympathetic innervation and is associated with vascular disorders. Later, these pains increase in intensity and may become continuous. In this phase pain does not permit a moment of relaxation to these unhappy patients.

Extension of the tumor to involve the nerves adjacent to pelvic structures leads to pain referred to the lower extremities (Cutler and Buschke¹⁵). During investigations that I have carried out in connection with treatment of pain in cases of carcinoma of the cervix uteri with physiologic interruption of the sympathetic innervation of the organs of the pelvis, I have observed two different effects¹⁶. In some cases the anesthetic block of the lumbar sympathetic chain relieved the pain only during the period of action of the anesthetic, in other cases

¹⁶ de Sousa Pereira, A. A Basis for Sympathetic Surgery in Cancer of the Cervix Uteri, Arch Surg, to be published.

the pelvic pain was relieved for a longer time. These observations suggest two different mechanisms in sympathetic pain of carcinoma of the cervix uteri. Probably in the first cases an organic and permanent stimulation of the sympathetic innervation from invasion of the tumor was responsible for the pain. In the latter cases the relief of pain for a period exceeding the normal anesthetic action of the procaine hydrochloride suggests the participation of another factor, probably vascular. Possibly the neoplastic lymphangitis stimulates the perivascular innervation to provoke vasoconstriction and to induce pain. One can suppose that the pain will disappear when the vasoconstriction is relieved by interruption of the sympathetic innervation.

In the mechanism of pain in cancer of the cervix uteri, the direct stimulation of the sympathetic innervation by the neoplastic growth is accepted. In these cases the hypogastric plexus and its branches are the sympathetic nerves principally responsible for pelvic pain. But when the perivascular innervation is stimulated by simple or neoplastic lymphangitis, then it is principally through the sympathetic innervation of the vessels that the painful sensations are carried. Leriche⁷ suggested that in cancer of the uterus pain is dependent on a simple or a neoplastic lymphangitis surrounding the arteries of the pelvis, embracing them compressing their walls and passing with them up to the neighborhood of the sympathetic branches coming from the lumbar sympathetic chain. However, personal investigations that I have carried out on the innervation of the veins¹⁷ and lymphatic vessels suggest that stimulation of the innervation of these blood vessels may also induce pain. Thus I believe that in the vascular mechanism of pain in cancer of the uterus the innervation of arteries, veins and lymphatic vessels stimulated by the neoplastic lymphangitis or by the neoplastic cells also plays a part. By this analysis of the mechanism of pain in cancer of the uterus one arrives at the conclusion that the painful sensations originating in the pelvic structures invaded by the neoplastic growth may reach the lumbar sympathetic chain, the spinal roots and the cord, running along the hypogastric plexus or through the innervation of the arteries, veins and lymphatic vessels. When the branches of the hypogastric plexus and the perivascular innervation are both stimulated by the neoplastic growth, then the two pathways are responsible for pain.

This interpretation of the pathways of pain in cancer of the uterus explains the reason why resection of the hypogastric plexus was successful in certain cases (Fulcher¹¹ and Leriche) and not successful in other cases (Atlee¹⁰ and Fontaine and Herrmann⁶). Probably in the cases in which the interruption of the hypogastric plexus was

¹⁷ de Sousa Pereira, A. The Innervation of the Veins. Its Role in Pain, Venospasm and Collateral Circulation, to be published.

not followed by complete relief of pelvic pain, the perivascular innervation was stimulated by lymphangitis or by cells of the neoplastic growth which may be responsible for pain. On the other hand, one can understand why Leriche¹⁸ obtained relief of pain by periarterial sympathectomy, interrupting the afferent perivascular pathways of the pelvic vessels.

These facts suggest that to obtain complete relief of pelvic pain in cancer of the cervix uteri it is necessary to interrupt the pathways of painful sensations that run along the hypogastric plexus and also the afferent pathways that follow the perivascular innervation.

On the other hand, it is known that the visceral pain from cancer of the cervix uteri is relieved only while the neoplastic growth is contained within the area anesthetized by the surgical interruption of the sympathetic innervation. When the tumor invades the sympathetic or the somatic innervation of the structures beyond this area, pain reappears. Therefore, to obtain complete relief of pain in cancer of the cervix uteri for a long period during the extension of the tumor it is necessary to interrupt the pathways that run along the hypogastric plexus and the perivascular innervation in a large area and at a high level. This may be obtained by performing in the same operation resection of the hypogastric plexus and lower part of the aortic plexus, interruption of the lower part of the lumbar sympathetic chains and periarterial sympathectomy of the iliac and mesenteric arteries.

ANATOMICOPHYSIOLOGIC BASIS AND TECHNIC OF ABDOMINOPELVIC SYMPATHECTOMY

Different types of abdominopelvic sympathectomy have been performed by several surgeons and by me. In all cases the sympathetic innervation of the uterus was interrupted by a transperitoneal approach after previous laparotomy. Resection of the hypogastric plexus, periarterial sympathectomy of the mesenteric or the common iliac arteries, resection of the aortic plexus and resection of the lumbar chains unilaterally or bilaterally have been practiced alone or in combination.

The uterus derives its sympathetic nerve supply mainly from the hypogastric plexus (Piersol,¹⁹ Gray,²⁰ White and Smithwick²¹ and

18 Leriche, R. *Surgery of the Sympathetic System. Indications and Results*, Ann Surg **88** 449, 1928, footnote 5.

19 Piersol, G. M. *Human Anatomy*, Philadelphia, J. B. Lippincott Company, 1930, p. 1373.

20 Gray, H. *Anatomy of the Human Body*, edited by W. H. Lewis, Philadelphia, Lea & Febiger, 1936, p. 917.

21 White, J. C., and Smithwick, R. H. *The Autonomic Nervous System*, New York, The Macmillan Company, 1944, p. 385.

Kuntz²²) and secondarily from the nerve fibers that accompany the hypogastric vessels. The hypogastric plexus (fig 1) is the continuation of the aortic plexus, which is made up of nerve branches derived from the celiac plexus and from the lumbar sympathetic chains. At about the level of the first sacral vertebra, the hypogastric plexus



Fig 1—Abdominopelvic sympathetic innervation. *A*, aortic plexus, *B*, hypogastric plexus, *C*, inferior mesenteric plexus, *D*, lumbar sympathetic chain, *E*, pelvic plexus.

divides into two distinct nerves that course obliquely from above downward in the lateral rectal space and terminate in a mass of nerve fibers

²² Kuntz, A. *The Autonomic Nervous System*, Philadelphia, Lea & Febiger, 1934, p. 340.

and ganglionic cells which has been named the hypogastric ganglion (fig 2) by Frankenhaeuser. The visceral branches to the pelvic organs originate from this ganglionic plexus, which is also connected with the second, third and fourth sacral nerves. This plexus is intimately connected with the uterosacral ligaments.

Afferent sensory fibers conducting painful sensations from the uterus run along the hypogastric and aortic plexuses and through the lumbar sympathetic chain to reach the spinal cord through the eleventh and



Fig 2—Sympathetic innervation of the uterus. *A*, common iliac artery, *B*, hypogastric artery, *C*, ureter, *D*, bladder, *E*, uterus, *F*, vesical plexus, *G*, uterine plexus, *H*, vaginal plexus, *I*, vagina, *J*, rectum, *K*, hypogastric plexus, *L*, lumbar sympathetic chain, *M*, right pelvic plexus, *N*, sacral sympathetic chain, *O*, second sacral ganglion, *P*, third sacral ganglion, *Q*, fourth sacral ganglion, *R*, hypogastric ganglion, *S*, hemorrhoidal plexus.

twelfth thoracic nerves. The sensory fibers that accompany the hypogastric and common iliac vessels probably run also through the lumbar sympathetic chain before reaching the spinal cord.

The efferent pathways that reach the uterus through the hypogastric plexus and through the perihypogastric innervation exert a vasoconstrictor action on the vessels of the internal genital organs.

These facts concerning the anatomy and physiology of the sympathetic innervation of the uterus are of great importance in planning the relief of pain in cancer of the uterus by abdominopelvic sympathectomy. To obtain complete relief from pain, it is necessary to interrupt the afferent pathways that run along the hypogastric plexus, along the hypogastric vessels and along the mesenteric artery. The periarterial sympathectomy of the inferior mesenteric artery is performed to relieve pain produced from invasion by cancer of the sigmoid mesocolon (fig 3)

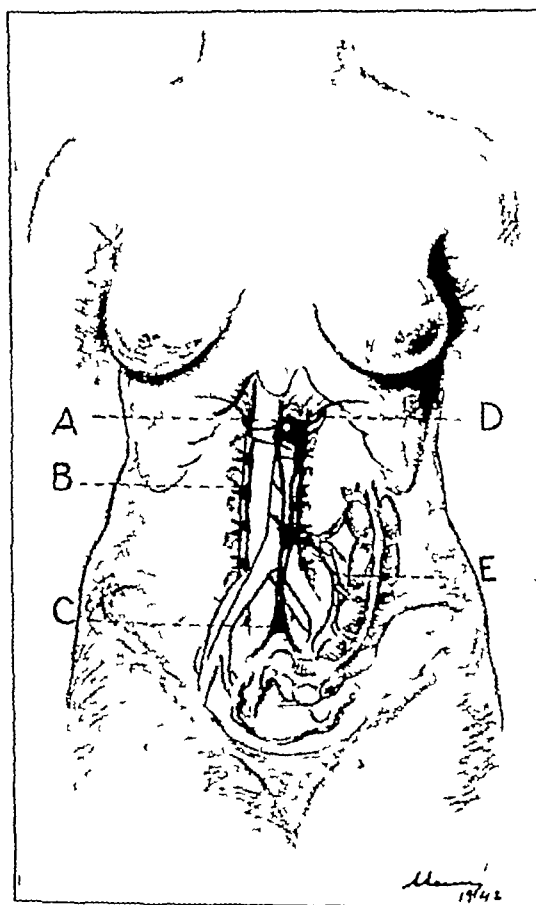


Fig 3 — Abdominopelvic sympathetic innervation and inferior mesenteric plexus. A, celiac plexus, B, lumbar sympathetic chain, C, hypogastric plexus, D, splanchnic nerves, E, inferior mesenteric plexus

And, as the cancer in its development invades progressively the adjacent structures, to obtain relief of pain for as long as possible it is necessary to perform an extensive abdominopelvic sympathectomy

Technic — In cases of resection of the hypogastric plexus, the abdomen is opened by a median subumbilical incision. In cases of extensive abdominopelvic sympathectomy the incision in the abdominal wall is

extended from the symphysis pubis to a point above the umbilicus. The patient is placed in the Trendelenburg position. The small intestines and colon are packed toward the diaphragm. After careful and complete examination of the pelvis to determine the extent of invasion of the tumor, abdominopelvic sympathectomy to relieve pain is planned accord-

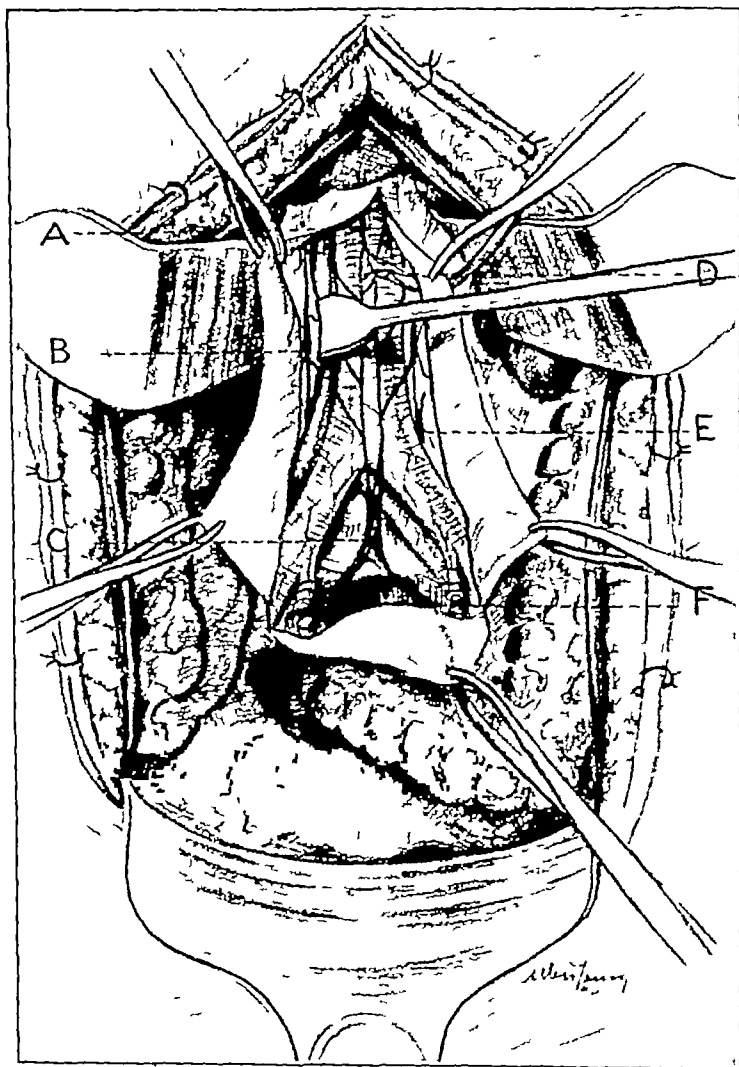


Fig 4—Approach to the abdominopelvic sympathetic system. A, lower part of aortic plexus, B, right lumbar sympathetic chain, C, hypogastric plexus, D, inferior mesenteric plexus, E, left lumbar sympathetic chain, F, pelvic plexus.

ing to the circumstances of each case. The posterior parietal peritoneum is incised in the midline over the portion of the lower abdominal aorta, just below the origin of the inferior mesenteric artery. The incision is carried downward below the bifurcation of the aorta. The peri-

toneum of the pelvis is then incised in a Y shape over the course of the right and left common iliac arteries to a point beyond the origin of the hypogastric arteries (fig 4) The hypogastric plexus that is involved by the retroperitoneal connective tissue is isolated anterior to the aorta and the fifth lumbar vertebra The right and left branches of the hypogastric plexus are isolated in the pelvis to a point near the hypogastric ganglionic plexus

Dissection is carried upward, and the roots of the hypogastric and aortic plexus derived from the lumbar chains are identified and isolated The fifth, the fourth and, in certain cases, the third lumbar ganglion of the lumbar chain may be isolated and resected The lower part of the aortic plexus above the origin of the inferior mesenteric artery is isolated as far as possible

The hypogastric plexus, the lower part of the aortic plexus and the lumbar sympathetic chains may be resected when they are being isolated or after previous complete isolation By this operation the hypogastric afferent pathways from the uterus are completely interrupted But to obtain complete interruption of the efferent pathways from the organs of the pelvis it is also necessary to interrupt the afferent pathways that follow the vessels, particularly the arteries Periarterial sympathectomy of the common iliac arteries and sympathectomy of the inferior mesenteric artery is required to complete the interruption of the afferent pathways from the pelvis

In the cases reported I have performed different types of sympathetic operations, from resection of the hypogastric plexus alone to the more extensive and complete abdominopelvic sympathectomy (fig 5) In all these cases, after the abdominopelvic sympathectomy ligation of the hypogastric arteries has also been done After these retroperitoneal operations, the peritoneum was closed by a continuous suture and the abdominal wall was closed in layers

ABDOMINOPELVIC SYMPATHECTOMY AND LIGATION OF THE HYPOGASTRIC ARTERIES PRECEDED BY RADIUM AND ROENTGEN RAY TREATMENT

As abdominopelvic sympathectomy is followed by an increased blood supply to the organs of the pelvis, it is important to know what influence this operation exerts in the development of cancer of the uterus

To clarify this question, in 2 patients with cancer of the cervix uteri suffering from pelvic pain, who had been treated previously by radium and roentgen rays, abdominopelvic sympathectomy was performed and supplemented by ligation of the hypogastric arteries, to reduce the danger of hemorrhage of the cervical cancer

CASE 1—*Carcinoma of the Cervix Uteri, Stage II*

E. M. C., a 29 year old woman, one month previously had begun to have pain low in the abdomen Gynecologic examination showed the cervix uteri to be

nodular and bleeding and the anterior vaginal fornix infiltrated. Biopsy of the cervix showed squamous cell carcinoma.

She was treated by roentgen rays (2,400 r) and application of radium to the vagina and uterus (50 mg), followed by gynecologic diathermy and roentgen



Fig 5—Abdominopelvic sympathectomy. *A*, lower part of the aortic plexus, *B*, right lumbar sympathetic chain, *C*, resection of hypogastric plexus, *D*, left lumbar sympathetic chain, *E*, periaarterial sympathectomy on inferior mesenteric artery, *F*, periaarterial sympathectomy on common iliac artery.

rays (16,600 r). During and at the end of the treatment, she complained of a great deal of pain low in the abdomen and low in the back. After the irradiation, the cervix healed. On April 13, 1940, with the patient under general anesthesia with ether, I performed resection of the hypogastric plexus and ligation

of the hypogastric arteries. Two months after the operation, the anterior vaginal fornix ulcerated. Five months after sympathectomy, there was no pain low in the abdomen or in the lumbosacral region but the patient complained of vaginal pain and rectal tenesmus. Gynecologic examination showed that the cervix uteri, the vaginal fornices and the superior third of the anterior wall of the vagina were ulcerated and the parametrium infiltrated. In the sixth month the condition of the patient became worse, inguinal metastases and a vesicovaginal fistula appeared, and there was much vaginal pain. The further course is not known.

CASE 2—*Carcinoma of the Cervix Uteri, Stage I*

E. R. C., a 29 year old woman, had for the last three months had a hemorrhagic discharge from the vagina. Gynecologic examination revealed the cervix uteri to be irregular and bleeding to touch. Biopsy showed basal cell carcinoma.

Roentgen rays (2,400 r) and radium treatment of the vagina (25 mg), followed by gynecologic diathermy and roentgen rays (16,530 r) were applied. The cervix uteri healed. On May 3, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus and ligation of the hypogastric arteries. Three months later the patient complained of abundant vaginal discharge, rectal tenesmus and vaginal pain, although she had no pain low in the abdomen or in the lumbosacral region. Gynecologic examination showed the cervix uteri to be ulcerated and bleeding and the vaginal fornices invaded by the cancer. Four months after the sympathectomy she complained of pain in the left sacroiliac region, radiating down to the groin and the internal aspect of the left thigh. Six months after the operation the cervix was ulcerated, the vaginal fornices were infiltrated and the left parametrium was invaded by the cancer, there was intense vaginal pain. After this time she did not return to the dispensary.

In these 2 patients with carcinoma of the cervix uteri, resection of the hypogastric plexus and ligation of the hypogastric arteries was followed by relief from pain low in the abdomen and low in the back. This relief was complete for about two (case 1) or three months (case 2). Then the cervix ulcerated, and the cancer quickly invaded the vaginal fornices, the wall of the vagina and the adjacent structures. Vaginal pain appeared. The general condition of both patients quickly became worse. About six months after the sympathetic operation, the general and local conditions were extremely poor.

ABDOMINOPELVIC SYMPATHECTOMY AND LIGATION OF THE HYPOGASTRIC ARTERIES FOLLOWED BY RADIUM AND ROENTGEN RAY TREATMENT

In spite of ligation of the hypogastric arteries, abdominopelvic sympathectomy performed to relieve pain in cancer of the cervix uteri provokes an increase in the development of the arterial collateral circulation in the organs of the pelvis. This postoperative increase in blood supply at the level of the vessels of the uterus and of the tumor has an adverse influence on the development of the cancer of the cervix uteri as the first 2 cases have shown. In the following 12 cases, postoperative irradiation by radium and roentgen rays was performed.

immediately after the abdominopelvic sympathectomy. In this way the increase of radiosensitivity of the tumor produced by the increased arterial blood supply, determined by vasodilatation, was utilized to favor the irradiation.

CASE 3—*Carcinoma of the Cervix Uteri, Stage II*

O J R, a 63 year old woman, had for two years had a vaginal discharge that in recent months had become hemorrhagic. Gynecologic examination showed the cervix uteri and the anterior fornix of the vagina to be ulcerated. Biopsy revealed adenocarcinoma.

The patient was treated by roentgen rays (2,400 r), and on March 30, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus followed by bilateral ligation of the hypogastric arteries. Immediately after the operation, radium (50 mg) was applied to the vagina and uterus, followed by gynecologic diathermy and roentgen rays (16,260 r). Six months later the cervix healed, but the patient complained of rectitis, the pain low in the abdomen and low in the back was absent after operation. Five years after the sympathectomy the cervix uteri remained healed, there were no signs of recurrence of metastasis and she had had no pelvic pain.

CASE 4—*Carcinoma of the Cervix Uteri, Stage II-III*

L A, a 62 year-old woman, had had for six months discharge from the vagina and pain low in the abdomen and in the lumbosacral region. Gynecologic examination showed an irregular and nodular cervix, bleeding easily to touch, the fornices were infiltrated. Biopsy showed basal cell carcinoma.

Roentgen rays (2,400 r) were applied, and on April 6, 1940, with the patient under general anesthesia induced with ether, I carried out resection of the hypogastric plexus, followed by bilateral ligation of the hypogastric arteries. After the operation, radium treatment (50 mg) to the vagina and uterus, gynecologic diathermy and roentgen rays (16,600 r) were applied. Five months after the sympathectomy the cervix uteri was healed, there was no pain or hemorrhage. One year later the cervix remained healed, without signs of recurrence or metastasis. The further course is not known.

CASE 5—*Carcinoma of the Cervix Uteri, Stage II*

M N O, a 46 year old woman, had for two months had a discharge from the vagina, with hemorrhage. Gynecologic examination showed the cervix uteri to be replaced by a large mass, bleeding easily to touch. The lateral vaginal fornices and the parametrium were infiltrated by the cancer. Biopsy revealed basal cell carcinoma.

On April 20, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus and ligation of the hypogastric arteries. This operation was followed by application of radium (50 mg) to the vagina and uterus, gynecologic diathermy and roentgen rays (16,600 r). Five months after the sympathectomy the cervix uteri was healed, and the patient remained well until one year after the operation. Then the cervix ulcerated, the cancer invaded the parametrium and pain appeared in the left sacroiliac region, radiating down to the groin and left lower extremity. The patient died five months later.

CASE 6—*Carcinoma of the Cervix Uteri, Stage III*

A S, a 36 year old woman, had for five months had a discharge from the vagina and sometimes hemorrhage and pain low in the abdomen and in the lumbo-

sacral region The cervix uteri was replaced by an irregular mass that bled when touched The lateral vaginal fornices and the right parametrium were infiltrated by the cancer Biopsy of the cervix showed basal cell carcinoma

The patient was treated by roentgen rays (2,400 r), and on April 27, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus and ligation of the hypogastric arteries Immediately after the operation, radium (40 mg) was applied to the vagina and uterus, followed by gynecologic diathermy and roentgen rays (16,600 r) Three months after the operation the cervix was healed, but the cancer recurred seven months after the operation, the cervix was ulcerated, and the vaginal fornices and parametrium were infiltrated by the cancer Two months later a vesicovaginal fistula appeared The patient remained without pain low in the abdomen or low in the back until one year after the sympathectomy, when she complained of pain in the right lumbosacral region, radiating down to the lower extremity on the same side The end result is not known

CASE 7—*Carcinoma of the Cervix Uteri, Stage II*

M C S, a 37 year old woman, had for three months had a discharge, with uterine hemorrhages for the last three weeks There were diffuse pains low in the abdomen Gynecologic examination showed the cervix uteri to be replaced by an irregular neoplastic mass, bleeding easily to touch The lateral fornices of the vagina were invaded by the cancer Biopsy of the cervix showed carcinoma of transitional cells

On May 18, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus and ligation of the hypogastric arteries Treatment of the vagina and uterus with radium (44.62 mg), gynecologic diathermy and roentgen rays (16,330 r) were applied postoperatively Six months after operation the patient complained of pain in the right sacroiliac regions, radiating down to the right lower extremity She did not come back to the dispensary

CASE 8—*Carcinoma of the Cervix Uteri, Stage I*

L G, a 34 year old woman, had abundant hemorrhages from the uterus for four months The cervix uteri was invaded by a tumor growth, bleeding to touch Biopsy showed basal cell carcinoma

Before the operation, roentgen rays were applied (2,400 r) On Sept. 9, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus, bilateral periarterial sympathectomy of the hypogastric arteries and ligation of both hypogastric arteries Radium treatment (50 mg) to the vagina and uterus, gynecologic diathermy and roentgen rays (16,600 r) were applied immediately after the operation For two months the patient remained well and without pain, then lumbosacral pain appeared, radiating down along the left sciatic nerve Seven months after the operation, the sciatic pain on the left side persisted Since that time the patient has not returned to the dispensary

CASE 9—*Carcinoma of the Cervix Uteri, Stage I*

B A M, a 38 year old woman, had discharge from the vagina and hemorrhages from the uterus for six months, with diffuse lumbosacral pain The cervix uteri was ulcerated Biopsy of the cervix uteri revealed basal cell carcinoma

The patient was treated by roentgen rays (2,400 r) On Aug 22, 1940, with the patient under general anesthesia induced with ether, I resected the hypogastric plexus and did a periarterial sympathectomy of the right common iliac artery and ligation of both hypogastric arteries Radium treatment (50 mg) of the vagina

and uterus, gynecologic diathermy and roentgen rays (16,600 r) were applied immediately after the operation. Three months later the cervix was healed and the pain low in the abdomen and in the lumbosacral region was absent. Four years after the operation the cervix uteri remained healed, and the patient had no pain low in the abdomen or low in the back, there were no signs of recurrence or metastasis. Nothing further is known about the patient.

CASE 10—*Carcinoma of the Cervix Uteri, Stage II*

C S, a 33 year old woman, five months before she was seen had a hemorrhage from the uterus and since then repeated hemorrhages. The cervix uteri was ulcerated and bleeding. The vaginal fornices were invaded by neoplastic infiltration. Biopsy showed basal cell carcinoma.

Roentgen rays (2,400 r) were applied, and on Aug 10, 1940, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus, periarterial sympathectomy of the common iliac arteries of the inferior mesenteric artery and ligation of both hypogastric arteries. Treatment of the vagina and uterus with radium (50 mg), gynecologic diathermy and roentgen rays (16,600 r) were applied postoperatively. Seven months after the operation, the cancer recurred. Nine months after the sympathectomy, pain appeared in the left lumbosacral region, radiating down the left lower extremity. Death occurred in 1941.

CASE 11—*Carcinoma of the Cervix Uteri, Stage III*

A V, a 40 year old woman, had had repeated hemorrhages from the uterus for four months. Lumbosacral pain was present. The cervix uteri was ulcerated and the parametrium infiltrated. Biopsy showed basal cell carcinoma.

Roentgen rays (1,500 r) were applied, on Nov 17, 1941, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus and the lower portion of the aortic plexus, periarterial sympathectomy of the inferior mesenteric artery and ligation of both hypogastric arteries. Radium treatment (50 mg) of the vagina and uterus, gynecologic diathermy and roentgen rays (990 r) were applied postoperatively. During a period of two and a half years, the cervix remained healed, there were no signs of recurrence or metastasis, and the patient was free of pelvic pain. Her further history is not known.

CASE 12—*Carcinoma of the Cervix Uteri, Stage I-II*

M P, a 57 year old woman, had hemorrhagic discharge from the vagina for five months. The cervix uteri and the vaginal fornices were ulcerated, and there was lumbosacral pain. Biopsy showed basal cell carcinoma.

This patient was treated by roentgen rays (1,200 r) and on Sept 30, 1941, with the patient under general anesthesia induced with ether, I performed resection of the hypogastric plexus of the lower portion of the aortic plexus, periarterial sympathectomy of the inferior mesenteric artery and sympathectomy of the fourth lumbar ganglion.

These sympathectomies were followed by ligation of the hypogastric arteries. Radium treatment (50 mg) of the vagina and uterus, gynecologic diathermy and roentgen rays (13,160 r) were applied postoperatively. Three months later the cervix was healed, but six months after the sympathectomy the cancer recurred and the cervix ulcerated. Seven months after the operation, the cervix remained ulcerated and the cancer had invaded the neighboring pelvic organs, however, the patient did not complain of pain in the pelvis or low in the back after the sympathetic operation. Nothing further is known about her.

CASE 13—*Carcinoma of the Cervix Uteri, Stage I-II*

M J B, a 46 year old woman, had a discharge from the vagina with hemorrhage for three months, with pain low in the abdomen and low in the back. There was edema of the left thigh. The cervix uteri was ulcerated and the left parametrium infiltrated. Biopsy showed a carcinoma of atypical cells.

Before operation, roentgen rays (2,400 r) were applied, and on Oct 9, 1941, with the patient under general anesthesia induced with ether, I resected the hypogastric plexus and the lower portion of the aortic plexus, did a sympathectomy of the fourth and fifth lumbar ganglions and a periarterial sympathectomy of the inferior mesenteric artery and ligated both hypogastric arteries. Radium treatment (50 mg) of the vagina and uterus, gynecologic diathermy and roentgen rays (2,650 r) were applied postoperatively. Four months after the operation, the cervix was healed and there was no pain low in the abdomen, the patient complained of pain in the external aspect of the left leg. Six months after the sympathectomy the cervix remained healed. She was treated by roentgen rays, and the pain in the left leg disappeared. After that time she did not return to the dispensary.

CASE 14—*Carcinoma of the Cervix Uteri, Stage II*

M J S, a 48 year old woman, had hemorrhagic discharge from the vagina and hemorrhages from the uterus for eight months. The cervix was ulcerated and bled abundantly, the vaginal fornices were infiltrated. Biopsy showed a basal cell carcinoma.

Roentgen rays (2,400 r) were applied before the operation. On Dec 13, 1941, with the patient under general anesthesia with ether, I performed resection of the hypogastric plexus and of the lower portion of the aortic plexus, bilateral interruption of the fourth and fifth lumbar sympathetic ganglion and periarterial sympathectomy of the inferior mesenteric artery, followed by ligation of the hypogastric arteries. Radium treatment (43 mg) of the vagina and uterus, gynecologic diathermy and roentgen rays (16,600 r) were applied postoperatively. Five months after the operation the cervix was healed and the patient was free from pain. Three years after the sympathectomy the cervix remained healed, the patient had no pelvic pain and there was no sign of recurrence or metastasis. She has not been seen since that time.

In this series of 12 cases the abdominopelvic sympathectomy was followed by application of radium and roentgen rays. On 5 patients with pain low in the abdomen or low in the back produced by carcinoma of the cervix uteri (stages II and III), resection of the hypogastric plexus and ligation of the hypogastric arteries was performed. In all cases pain disappeared completely after the sympathectomy, and the cervix healed. Five years later in 1 patient (case 3) and one year later in another patient (case 4), the cervix remained healed and without pain. In the other cases cancer recurred locally one year (case 5), seven months (case 6) and six months (case 7) following the hypogastric sympathectomy. It is interesting to observe that in 2 patients (cases 5 and 7) after local recurrence pain appeared at the level of the sacroiliac region, radiating down to the lower extremity. But in 1 case (case 6) cancer recurred without pain seven months following the resection of the hypogastric plexus. During the following

months, the cancer invaded the neighboring structures and a vesico-vaginal fistula appeared without pain. Only five months after the local recurrence (one year after the sympathectomy), the patient began to feel pain in the right lumbosacral region, radiating down to the lower extremity.

In the last 7 cases, interesting facts were observed. To the resection of the hypogastric plexus was added periarterial sympathectomy of the hypogastric or common iliac arteries—and in other cases, of the inferior mesenteric artery—resection of the lower portion of the aortic plexus and lumbar sympathectomy. In every case the cervix uteri healed after treatment by abdominopelvic sympathectomy and irradiation. One patient (case 9) after four years, another (case 14) after three years and another (case 11) after two years and a half remained healed and without pain, recurrence or metastasis. In another patient (case 13) the cervix healed, however, four months after the operation she complained of pain in the external aspect of the leg. This pain was completely relieved by roentgen ray treatment, and she remained healed and free of pain. In case 8 the cervix uteri healed and the patient was relieved of pelvic pain during two months, then appeared a sciatic pain on the left side. Cancer recurred locally in case 10 seven months after operation, only two months later lumbosacral pain appeared on the left side. A similar fact was observed in case 12. The cervix uteri ulcerated six months after the operation, cancer progressed and invaded the neighboring structures, but one month later the patient did not feel pelvic pain. These cases demonstrate that the patient remains free of pain while cancer invades the structures anesthetized by abdominopelvic sympathectomy. When cancer reaches the lumbosacral plexus, pain reappears, radiating down to the lower extremity.

COMMENT

At the same time that these investigations on the influence of abdominopelvic sympathectomy in the treatment of pain in cancer of the uterus were carried out, the influence of the blood supply in the development of cancer of the cervix uteri was also studied. In spite of bilateral ligation of the hypogastric arteries, abdominopelvic sympathectomy produces vasodilatation and increased development of the collateral circulation of the pelvic organs.¹⁶ This increased blood supply to the uterus has an adverse influence on the tumor if the application of radium and roentgen rays is not performed immediately after the sympathectomy. The first 2 cases of this series demonstrate this fact. In these patients, previously treated by radium and the roentgen ray, resection of the hypogastric plexus was performed, but radium was not applied after the sympathectomy. Respectively two and three months after the operation,

the cervix uteri ulcerated from neoplastic recurrence. In the next few months the cancerous invasion of the neighboring structures progressed quickly. Pain low in the abdomen and low in the back remained relieved, but five months later in the 1 case and three months later in the other vaginal pain caused by extension of the cancer appeared.

Resection of the hypogastric plexus, followed by immediate irradiation, gave a different result. In all these cases hypogastric sympathectomy relieved the pain low in the abdomen and low in the back. In 1 patient the cervix remained healed and there were no signs of recurrence or metastasis for five years, and in another the cervix remained healed one year. In the 3 remaining patients the cancer recurred respectively one year, seven months and six months after hypogastric sympathectomy. There was no pain low in the abdomen or low in the back except in the case in which the cancer recurred one year later, when pain appeared in the left sacroiliac region and radiated down the left lower extremity, in the other 2 cases pain appeared in the right lumbosacral region one year and six months respectively after the operation.

Comparing the results observed in the first 2 cases with the results obtained in these 5 cases in which resection of the hypogastric plexus was followed by radium and roentgen ray treatment, one deduces that the results were better when irradiation followed hypogastric sympathectomy.

In the remaining 7 cases, a more extensive sympathectomy was performed. To resection of the hypogastric plexus was added sympathectomy of the hypogastric arteries (1 case), sympathectomy of the right common iliac artery (1 case) and of the common iliac and inferior mesenteric arteries (1 case), sympathectomy of the inferior mesenteric artery and resection of the lower portion of the aortic plexus (1 case), and, finally, sympathectomy of the inferior mesenteric artery, resection of the lower portion of the aortic plexus and lumbar sympathectomy (3 cases). In 3 of these cases there was local healing and no recurrence, metastasis or pain during periods of four, three and two and a half years. In the fourth case the lesion of the cervix healed, then, four months after the operation, pain appeared in the external aspect of the left leg, but six months after the abdominopelvic sympathectomy the cancer of the cervix remained healed and the pain in the leg was relieved by roentgen ray treatment. In the remaining 3 cases there was recurrence of the cancer of the cervix. In 1 case the cancer recurred six months later and the cervix ulcerated, but the patient did not complain of pain low in the abdomen or low in the back during the period of observation. In the second case, two months after the operation the patient began to feel lumbosacral pain radiating along the left

sciatic nerve Seven months after the sympathectomy, the sciatic pain persisted but she did not feel pain low in the abdomen Finally, in the last case the patient remained well for seven months, when the cancer recurred Nine months after the operation the patient began to feel lumbosacral pain on the left side, radiating down to the left thigh, she died some time later

The results obtained in these cases, in which an extensive abdominopelvic sympathectomy was performed, show that the cancer may recur without pain, as happened in 1 case, or with pain, as was observed in 2 cases When pain occurred after the abdominopelvic sympathectomy, the patients did not feel abdominal pain in the fields of the sympathetic innervation They had only a somatic pain in the field of the innervation of the lumbosacral plexus In its development the cancer invaded the neighboring structures, and when the roots or branches of the lumbosacral plexus were stimulated by the tumor pain appeared and radiated down the lower extremity

These facts suggest that abdominopelvic sympathectomy relieves only the visceral sympathetic pain, which remains relieved while the tumor is localized within the area anesthetized by the sympathetic operation But when the tumor progresses and invades the field of the somatic innervation, only therapeutic action (chordotomy or other procedures) on the cerebrospinal nervous system may relieve the pain completely In the treatment of pain caused by cancer of the cervix uteri two problems may be observed the one sympathetic and the other somatic They may appear isolated in some cases or associated in others From the analysis of the mechanism of pain in each patient may be deduced the best therapeutic method, sympathetic or somatic, to relieve the intolerable pain

In these investigations I have tried to relieve pain in cancer of the cervix uteri by abdominopelvic sympathectomy followed by ligation of the hypogastric arteries, with the purpose of avoiding hemorrhage at the level of the ulcerated cervix It is known that abdominopelvic sympathectomy increases the blood supply to the cancer, and this favors the action of the radium and roentgen rays It will be necessary to perform another series of abdominopelvic sympathectomies, without ligation of the hypogastric arteries, to know whether there is any difference in the results when compared with those obtained in these investigations

SUMMARY

To determine the value of abdominopelvic sympathectomy in the treatment of intolerable pain in cancer of the cervix uteri, I have performed a series of sympathetic operations on 14 patients These operations were limited to resection of the hypogastric plexus in 7 patients,

but in the remaining patients there was added one or more of the following operations periarterial sympathectomy of the hypogastric, common iliac or mesenteric arteries, resection of the lower portion of the aortic plexus and lumbar sympathectomy

As abdominopelvic sympathectomy increases the blood supply and the development of the collateral circulation of the pelvic organs, I tried to lessen the risk of hemorrhage at the level of the ulcerated cancer by bilateral ligation of the hypogastric arteries. However, it is to be noted that, even when bilateral ligation of the hypogastric arteries is performed, after the operation there is an evident increase in the development of the collateral circulation, as I had already demonstrated in experimental investigations¹⁰. In this series of 14 cases, after the abdominopelvic sympathectomy there was no death caused by hemorrhage.

To analyze the influence of the increased blood supply caused by abdominopelvic sympathectomy in the development of the cancer, the treatment by irradiation preceded in 2 cases resection of the hypogastric plexus, and in 5 cases radium was applied postoperatively during the phase of vasodilatation of the pelvic vessels. The results obtained reveal the quick recurrence and development of cancer of the cervix when abdominopelvic sympathectomy was preceded but not followed by irradiation. Much better were the results when the application of radium was performed during the increased blood supply caused by vasodilatation following the sympathetic operation.

The extensive abdominopelvic sympathectomy, in which resection of the lower portion of the aortic plexus was added to resection of the hypogastric plexus, lumbar sympathectomy and periarterial sympathectomy of the common iliac, hypogastric or mesenteric arteries, demonstrated that the visceral sympathetic pain remains relieved during the period in which the cancer remains within the anesthetized area. If the cancer progresses and invades the lumbosacral plexus, pain appears, radiating down to the lower extremity. As there may exist a sympathetic or a somatic pain or both in cancer of the cervix uteri, two therapeutic problems, the one sympathetic and the other somatic, must be analyzed according to the type of mechanism of pain. From these investigations it is deduced that abdominopelvic sympathectomy relieves only the visceral sympathetic pain and must be followed by adequate treatment by radium and the roentgen ray.

PREOPERATIVE DIAGNOSIS OF RECENT WOUNDS OF THE ABDOMEN

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THE results of present day management of war wounds of the abdomen are superior to those obtained in previous wars. This is due to many factors, both military and medical. One such factor is the application of sound surgical principles. The procedures suggested in directives are based on such principles, and to carry out these procedures, correct preoperative diagnosis is essential. For wounds of the abdomen, diagnosis may be simple, but in my experience problems are frequently encountered.

In preoperative diagnosis of abdominal wounds, not only the intra-peritoneal structures but also the structures adjacent to them, particularly the genitourinary organs, must be considered. Similarly, in preoperative diagnosis of intra-abdominal injury, wounds of the chest, the back, the perineum and the thighs must also be evaluated. For this reason, an orderly method of diagnosis is always carried out. This routine depends on the painstaking employment of time-honored methods of physical diagnosis, enhanced by simple roentgenologic and laboratory aids.

The greatest aid to diagnosis is the determination of the course of the missile. This is arrived at as the diagnostic steps are carried out. These steps are evaluation of the general condition and complaints of the patient, inspection of the wounded areas, palpation for foreign bodies, palpation and auscultation of the abdomen and chest, palpation of the renal region, urethral catheterization and urinary examination, digital examination of the rectum, inspection of the gastric contents and roentgen ray studies. Not all these steps may be necessary, but even with the use of all of them a diagnosis may still remain incomplete. Nothing can replace experience as a teacher. In this paper it is intended only to point out the aids to diagnosis which have been employed, the difficulties encountered and the pitfalls in the interpretation of these procedures.

The conclusions drawn after one has gone through an orderly routine of preoperative diagnosis should answer the following questions: 1. Has the peritoneal cavity been perforated? 2. Regardless of perforation of the peritoneum, is there a possibility that some intra-abdominal catastro-

phe has occurred? 3 What structures, intraperitoneal or adjacent thereto, are probably involved?

It can then be determined whether the abdomen must be opened, which type of incision is most suitable and what extra-abdominal procedures should be accomplished

COURSE OF THE MISSILE

By being able to trace the course of the missile, one may gain more information than by any other means. Missiles can travel long distances in the body to enter the abdomen, and any wound of the abdominal wall, the back, the buttocks or the perineum is to be suspected. Projectiles which enter from the lower part of the chest and the thigh also frequently penetrate into the belly. Actually, no place on the body is completely exempt as a possible wound of entrance into the abdomen. Case 1 records a not unusual moderately long course of a missile.

CASE 1.—In a 24 year old man the wound of entrance was immediately beneath the middle third of the right clavicle. There was evidence of fluid in the right side of the chest. The abdomen was normal on examination. A foreign body was palpable below the right twelfth rib posteriorly. Roentgenologic examination showed the palpable foreign body and fractures of the third, the fourth and the fifth rib anteriorly, with some haziness of the entire right side of the chest. With this information, the path of the missile could be plotted. It entered under the clavicle, probably traveled in the thoracic wall to the site of the three fractured ribs, entered the thoracic cavity and traversed the diaphragm and the liver to stop subcutaneously. A thoracotomy and laparotomy were done, and the preoperative diagnosis of the course of the projectile was confirmed.

If there is one wound of the skin, two possibilities are present. Either the fragment has penetrated into the body and is still there, or the wound is a lacerated or an avulsed one and contains no foreign body. If the fragment is in the body and if it is superficial, it may be palpable. Nearly all foreign bodies encountered in war wounds are metallic, and proper roentgenograms will demonstrate them. Usually it is a simple matter to decide what must be examined roentgenologically, but if the foreign body is not seen on the roentgenograms roentgen examination of other areas is indicated. Thus, the course from entrance to missile is roughly known. Rarely do two missiles enter through the same wound. Yet case 2 demonstrates a multiplicity of foreign bodies and only one wound.

CASE 2.—The wound of entrance in a 19 year old youth was lateral to the left hip. The abdomen was rigid and tender. The rectum was full of feces, but there was no blood on the examining finger and no laceration was palpated. Catheterized urine contained no blood. The left leg was externally rotated. Roentgenologic examination showed many foreign bodies in the pelvis. Two of these fragments were similar in appearance to small caliber bullets. (This man had been wounded by a potato masher type of grenade.) The head of the left femur

and the acetabulum were severely comminuted. At laparotomy, a jagged rectal laceration was found. This tear was both intraperitoneal and extraperitoneal and was 3 inches (7.6 cm) long. The sigmoid colon was also lacerated. Bone fragments from the femur and the acetabulum were recovered throughout the peritoneal cavity. The metallic bodies seen on roentgenologic examination were mainly intraperitoneal, but a few were removed from the abdominal wall.

Since there is no foreign body in the avulsed or lacerated wound, the extent of damage is estimated by inspection. Some avulsed wounds include peritoneum and may be associated with evisceration. A large jagged shell fragment which avulsed a portion of the abdominal wall may lacerate structures some distance from the wound. If such a fragment then drops off the wound without having been seen, it may be difficult at laparotomy to explain the findings. In case 3, no foreign body had been seen by the patient and none was demonstrable by roentgenologic examination. The intra-abdominal pathologic change could be explained only if some portion of a large missile had penetrated into the pelvis at the moment of impact and then fallen from the body.

CASE 3—The patient was a 21 year old man. There was an avulsed wound of the left anterior abdominal wall, with evisceration of many coils of small bowel. Roentgenologic examination showed no foreign body. At operation a 10 inch (25.4 cm) segment of eviscerated jejunum, which was severely lacerated, was resected and an end to end anastomosis done. Several other tears of eviscerated jejunum were repaired. All bowel was then returned to the peritoneal cavity and the remainder of the peritoneal contents explored. Lacerations of the ileum, the sigmoid colon and the intraperitoneal portion of the rectum were found and repaired and a sigmoid colostomy performed. In addition, laceration of the gastrosplenic ligament and the great omentum necessitated suture.

When the peritoneum remains intact in the avulsed or lacerated wound or in the superficial penetrating wound, the possibility of intra-abdominal catastrophe from the sheer force of the blow must be reckoned with. Case 4 demonstrates intra-abdominal pathologic change without peritoneal penetration.

CASE 4—A 19 year old youth had a wound of the abdomen at the right costal margin in the midclavicular line. There was moderate tenderness and rigidity in the right upper quadrant. The roentgenograms showed a large foreign body immediately beneath the wound of entrance. At operation the wound of entrance was debrided, exposing the lower costal cartilages. The foreign body was wedged between the cartilage and the peritoneum, the latter being intact. After the missile was removed, because of its size and location, the abdomen was surgically explored. About 200 cc of free intraperitoneal blood and a moderate-sized stellate tear of the anterior surface of the right lobe of the liver were found.

If more than one wound of the skin is present again there are two possibilities: first, that the wound is a perforating one, the missile having

entered into and exited from the body and, second, that there are multiple penetrating wounds or some combination of penetrating, perforating, avulsed or lacerating wounds. In a perforating wound no foreign body will be demonstrable by roentgenologic examination, but the track of the missile can be visualized from the alinement of the points of entrance and exit. The track can nearly always be thought of as a straight line. Most of the apparently bizarre courses taken by fragments are due to the position occupied by the body when it is struck. If the crouch, bend or twist could be reduplicated, the path of the missile would usually be found to be reasonably straight. By questioning, one is frequently able to ascertain the position the patient was in at the moment he was wounded. The number of bizarre missile tracks found unrelated to the position are few, though they do occur. In multiple wounds, the diagnostic difficulties are often great, and it may be impossible to form definite conclusions as to tracks. Usually, in multiple wounds, only a few concern the abdomen, thus simplifying the problem to some extent. Case 5 is one of multiple wounds.

CASE 5—In a 22 year old man there were four wounds in the following locations: the left side of the back near the fourth lumbar vertebra, the right side of the back near the second lumbar vertebra, the abdomen at the right costal margin in the midclavicular line and the left lateral abdominal wall opposite the umbilicus. This last wound had a bullet partially protruding from it. Roentgenologic examination showed only the visible bullet. Here, then, were two perforating wounds, and their courses could be visualized. At operation the courses were easily traced as follows: 1. The fragment which entered near the second lumbar vertebra on the right coursed below the kidney, lateral to the duodenum, perforated the transverse colon near the hepatic flexure four times and perforated the liver 2 inches (5 cm.) from its anterior edge to exit on the anterior abdominal wall. 2. The fragment which entered on the left, near the fourth lumbar vertebra, perforated the descending colon three times, lacerated 8 inches (20.3 cm.) of jejunum and came to rest partially through the left lateral abdominal wall.

In the region of the buttocks, the thighs and the perineum, one often sees a series of wounds caused by the same missile. Case 6 is a simple illustration.

CASE 6—The patient was a 31 year old man who had two wounds of the left thigh, one medial and one lateral, two wounds of the scrotum and one of the medial surface of the right thigh. Roentgenograms showed a foreign body in the right thigh. This missile had entered on the lateral side of the left thigh, exited medially, entered and exited from the scrotum and finally penetrated the right thigh, where it stopped.

Perforating wounds in which the projectile courses near the inguinal ligament may be confusing for the reason that there may be three wounds and no foreign body demonstrable on the roentgenogram. This is illustrated in case 7.

CASE 7—In a 24 year old man, there were three wounds, one on the lateral side of the upper third of the left thigh, one just lateral to the scrotum at the inguinal fold and one of the right lower quadrant of the abdomen. The abdominal wound was 2 by 4 inches (5 by 10 cm), and through it many loops of small bowel were eviscerated. The lower half of the abdominal wall was extremely protuberant. Roentgenograms revealed no abnormalities. A midline incision in the lower part of the abdomen showed the abdominal protuberance to be the manifestation of evisceration of bowel in the track of the missile. After all bowel had been returned to the peritoneal cavity, the path of the missile was traced from the lateral wound of the left thigh to the wound of the right lower quadrant of the abdomen. The missile had torn the skin in the inguinal fold during its passage but had not exited there.

In perforating wounds, it is well to know which is the wound of entrance and which the wound of exit. There is nearly always more tissue damage on exit, both to the deeper structures and to the skin. Hence the wound of exit is larger, and there is a greater probability of visceral damage in its vicinity.

GENERAL CONDITION AND COMPLAINTS OF THE WOUNDED

Among the factors influencing the appearance of the patient are the number and severity of the wounds, the amount of hemorrhage and shock, the prior treatment, the time elapsed since injury and the ease with which he was transported. Therefore, the condition of a man with no abdominal injury may appear critical in contrast to that of a patient who, although he appears well, has definite intra-abdominal pathologic change. Early, the amount of shock or state of alertness may not be of help in accurate diagnosis. As the patient responds to treatment for shock, one gathers more information. His statements concerning abdominal pains are then worth considering but must be weighed along with all other findings. A man with two wounds of the anterior abdominal wall and no foreign body demonstrable by roentgenologic examination could have a perforating wound of the wall only or one which traversed some portion of the peritoneal cavity. A rapid recovery from shock and no complaints thereafter would favor the former diagnosis. A complaint of abdominal pain does not necessarily point to intra-abdominal pathologic change, for wounds of the abdominal wall or adjacent structures may be extremely painful and simulate intra-abdominal catastrophe.

Although there were two abdominal wounds in case 8, the patient recovered rapidly from shock. He then had no abdominal rigidity. For these two reasons, in spite of continued abdominal pain and tenderness, the preoperative diagnosis was a perforating wound of the abdominal wall without peritoneal perforation.

CASE 8—In a 38 year old man there was a wound just to the left of the umbilicus and one at the same level in the left midaxillary line. The blood

pressure was 80 systolic and 60 diastolic on entry, and the patient appeared ill. He complained of severe abdominal pain. After the administration of 1,000 cc. of blood, his blood pressure rose to 128 systolic and 70 diastolic and his general appearance was excellent. He still complained of abdominal pain but had no abdominal rigidity. At operation the wound was found to course through the rectus and the oblique muscles and not to involve the peritoneum.

Vomiting is not particularly indicative though hematemesis signifies esophageal or gastric damage if the possibilities of swallowed blood have been eliminated. In case 9, there was hematemesis but no laceration of either the stomach or the esophagus. There was a tear of the gastrohepatic ligament and severe trauma in the vicinity of the stomach.

CASE 9—The patient was a 27 year old man with one wound to the left of the xiphoid process and one posterior to the left transverse process of the first lumbar vertebra. Copious hematemesis was present. Abdominal rigidity was severe. Roentgenologic examination showed only a fracture of the left transverse process of the first lumbar vertebra. At laparotomy, the abdomen was found to be full of blood. The liver was severely macerated, the upper pole of the left kidney was lacerated and the gastrohepatic ligament was partially detached from the stomach. The path of the missile was demonstrated as follows: It had entered through the left transverse process of the first lumbar vertebra, had lacerated the upper pole of the left kidney, had penetrated the posterior peritoneum medial to the esophageal-cardiac angle, had lacerated the gastrohepatic ligament, had macerated the liver and had exited through the costal cartilage to the left of the ensiform process.

In blast injuries in which there is abdominal injury without any wound, vomiting may be one of the few signs which aid in determining whether there is actual intra-abdominal pathologic change.

Fever is no aid in early diagnosis, and even in late diagnosis so many variable factors produce a fever that it does not often offer much help.

LOCAL INSPECTION

Much information is available from an inspection of the wounded areas. The location of the wound has been discussed in its relation to plotting the course of the missile. As evisceration is self evident, the diagnostic concerns are the location of the foreign body, if any, and the extent of the damage to the intraperitoneal and adjacent organs. Subcutaneous evisceration may cause a protuberance of the abdominal wall, which resembles the swelling of a hematoma (case 7).

Frequently, a circumscribed hematoma points to the resting point of the fragment. In case 10, the whole track of the missile was outlined by a hematoma.

CASE 10—In a 67 year old woman, there were two wounds of the anterior abdominal wall, one to the right of the umbilicus and one near the right iliac crest. Connecting the two wounds was a visible hematoma. As this woman had a pendulous abdomen, it was decided that the hematoma could signify only a fairly superficial track. The diagnosis of no peritoneal perforation was confirmed at operation when the wounds were debrided and inspected.

Secretion of any type from a wound merits study. Wounds of the groin, the buttocks or the sacral area which exude a watery liquid are practically certain to communicate with the bladder or the urethra. The smell of urine is usually detectable in these instances (case 11).

CASE 11—In a 24 year old man there was a wound of the left buttock near the anus. From this wound slowly oozed clear liquid of the odor of urine. The abdomen revealed no abnormalities at examination. Rectal examination disclosed a severe laceration of the rectal wall, and blood presented itself on the examining finger. Roentgenologic examination showed a foreign body in the pelvis. Attempts to catheterize failed, the catheter entering for about 7 inches (18 cm). At operation the course of the missile was traced through the left buttock, in and out of the extraperitoneal portion of the rectum, through the prostatic portion of the urethra and into the prostate. There was no intraperitoneal injury. The foreign body was not recovered, as it was felt inadvisable to prolong the operation. (The treatment had consisted in laparotomy, sigmoid colostomy, suprapubic cystostomy, passage of a catheter through the urethra from above, coccygectomy and debridements and application of a plaster cast for fractures of the left calcaneus and the tibia.)

Feces or a fecal odor escaping from a wound indicates perforation of the bowel, particularly the colon. This is unusual in anterior abdominal wounds unless there is evisceration. Occasionally it occurs in wounds of the flank or back which communicate with retroperitoneal portions of the colon.

Hemorrhage from a wound seldom aids in diagnosis, for severe bleeding may occur in superficial wounds or wounds of muscle. But if pressure dressings do not control the hemorrhage, it may be that the bleeding comes from some intra-abdominal or retroperitoneal structure. In cases of thoracoabdominal damage, blood flowing from the external wound may have its source in a hemothorax. In case 12, there was a moderately profuse hemorrhage from the thoracic wound. This was shown to be from a hemothorax which was caused by a laceration of the liver and by severance of intercostal vessels.

CASE 12—The patient was a 22 year old man. There was a wound over the right tenth rib in a line with the angle of the scapula. Bleeding from this wound was profuse. There was abdominal rigidity but no tenderness. Roentgenologic examination showed haziness of the right pulmonary field and two foreign bodies which were anterior and lateral on the right in the vicinity of the ninth rib. It was difficult to tell from the roentgenogram whether these foreign bodies were in the liver. A limited thoracotomy was done through the ninth interspace, resecting the fractured ends of the eighth, ninth and tenth ribs. The severed intercostal vessels were ligated. The diaphragm was found to be lacerated for 3 inches (7.6 cm), and there was a shallow laceration of the liver immediately beneath the diaphragmatic tear. The foreign bodies were in the wall of the chest. The lung showed only a minor contusion of the lower portion of the lower lobe. These missiles had entered posteriorly through the tenth rib, lacerated the diaphragm and the liver and immediately exited from the

thoracic cavity, through the eighth and ninth ribs more anteriorly, to stop in the thoracic wall

In case 13 prompt diagnosis and priority operation were life saving

CASE 13—In a 30 year old man there was one wound of the anterior right abdominal wall at the costal margin and one wound on the right side of the back at the crest of the ilium. The abdomen was rigid to palpation. Roentgenologic examination showed no foreign body. The posterior wound bled profusely, and no amount of pressure sufficed to control it. Major retroperitoneal bleeding was diagnosed and an immediate laparotomy performed. The ascending colon was mobilized and retracted medially disclosing a completely transected bleeding kidney. The blood had coursed down the muscles of the back retroperitoneally to flow out the wound of exit. In addition, the liver was severely lacerated, but all its hemorrhage had remained intraperitoneal.

Although swelling of the scrotum may result from local hemorrhage, it may also be caused by extravasation of urine

PALPATION OF THE ABDOMEN

For a wounded patient, palpation of the abdomen is important chiefly for the demonstration of rigidity. Nearly any abdomen containing appreciable amounts of free blood or free gastrointestinal contents will demonstrate rigidity. (Case 18 was an exception.) Nearly all wounded patients have received morphine prior to their admission to the hospital. Rigidity, however, is not affected by narcosis to the same degree as is tenderness. Tenderness and rebound tenderness are valuable but depend on the time factor, the damage to the abdominal wall and adjacent structure and the personal equation more than does rigidity. Partial or complete severance of the anterior abdominal musculature may interfere with or abolish abdominal rigidity in spite of intra-abdominal pathologic change. The renal region should be palpated, but tenderness there does not in itself signify renal damage. Altogether, one can be easily misled by abdominal palpation. At times intra-abdominal injuries will be masked because of herniation of the affected organs into the chest. Few abdominal signs or symptoms may be present with hemorrhage or spillage retroperitoneally or into the lesser omental cavity. It is not at all unusual to find a badly lacerated spleen in a patient in whom abdominal examination has shown nothing significant. In these instances, the amount of free intraperitoneal blood is small (case 14).

CASE 14—The patient was a 23 year old man. There were three wounds on the left side of the back in the region of the tenth and eleventh ribs and three on the right side of the back at the lower costal margin. The abdomen was normal on examination. Roentgenologic examination showed fluid in the left side of the chest, numerous foreign bodies beneath the wounds and two foreign bodies in the region of the dome of the left diaphragm. At operation all wounds were debrided. One of these on the left, over the tenth interspace, was found to suck. Through it, a tear in the diaphragm was seen. A limited thoracotomy

was done, not by resecting but by cutting across the tenth rib anteriorly for exposure. After the diaphragmatic opening had been enlarged, a severely lacerated spleen was encountered and splenectomy performed. The two foreign bodies were recovered in the hilus of the spleen.

Severe abdominal rigidity may occur without any intra-abdominal pathologic change. This is particularly true in wounds which damage the hip, the pelvic girdle or the spine (cases 15 and 20).

CASE 15—In a 39 year old man there were four wounds, one of the right buttock, one of the scrotum and two of the right thigh. The abdomen was rigid. Rectal examination showed nothing abnormal. By catheterization clear urine was obtained. The roentgenograms showed a fracture of the right femoral head, the acetabulum and the ramus of the right ischium and the pubis. The femoral head was completely detached and appeared to be within the pelvis. At operation the wounds were debrided and the femoral head found free, anterior, below and medial to the acetabulum. No opening into the bladder or the peritoneum was found, and no laparotomy was done. The abdominal rigidity of this patient disappeared within forty-eight hours after operation and no abdominal symptoms developed.

When intraperitoneal damage is suspected in the absence of a cutaneous wound, such as occurs in severe concussion or blast, abdominal palpation is an important factor in diagnosis but not in itself conclusive.

DIGITAL EXAMINATION OF THE RECTUM

Rectal palpation contributes a great deal of information. A tear of the rectal wall or an adjacent foreign body may be palpable. If the course of the missile suggests rectal damage, the presence of blood on the palpating finger is confirmatory evidence (case 11). It is important to cleanse blood from the anus or any adjacent wound prior to palpation so that blood on the glove is not introduced. The absence of palpable damage or visible blood does not exclude rectal damage (case 2). The region of the prostatic and membranous portions of the urethra also is palpable rectally, and if a catheter is passed simultaneously through the urethra one can often determine the point of injury or obstruction. In case 16, the rectal examination and the urethral catheterization were completely misleading, but enough other aids to diagnosis were present (the path of the projectile and the abdominal rigidity) so that proper procedures were carried out.

CASE 16—In a 23 year old man there was one wound of the right inguinal region and one posteriorly to the left of the coccyx. The abdomen was rigid. Rectal palpation was noncontributory. Catheterized urine was clear, and no urethral obstructions were noted. Roentgenologic examination revealed nothing abnormal. This was then considered to be a perforating wound with intra-abdominal pathologic change. It was thought that no damage to the bladder or the urethra or low in the rectum existed. A laparotomy was done, disclosing one wound of the terminal portion of the ileum and a tear of the intraperitoneal

portion of the bladder While the bladder was being inspected, a tear of its posterior wall which opened directly into the rectum was seen A coccygectomy, which revealed a tear of the posterior rectal wall, was done at the conclusion of the abdominal operation (colostomy, repair of the ileum, suprapubic cystotomy and repair of the bladder)

In case 17, in spite of the results of rectal examination, a laparotomy was not performed because the course of the missile was demonstrated to be extraperitoneal and because there was no abdominal rigidity

CASE 17—In a 19 year old youth there was one wound of the left inguinal area There was a small wound in the midline of the anterior abdominal wall midway between the symphysis pubis and the umbilicus The abdomen was not rigid, but both lower quadrants were tender Rectally, a foreign body was palpable posterior to and to the right of the rectum, and the tip of the coccyx was roughened and mobile Roentgenologic examination showed a fracture of the left ischium and the inferior ramus of the pubis and a foreign body posteriorly below the coccyx Urethral catheterization yielded clear urine At operation the inguinal wound was debrided and found to lead to the fractured ischium A coccygectomy was then done the coccyx found fractured and the foreign body recovered from the posterior rectal wall There was no perforation of the rectum, though the posterior muscle coat was lacerated A track led from the site of the foreign body to the fractured ischium and pubis, at which point contact was made with the track from the inguinal wound The abdominal wound was found to contain a small foreign body which had not penetrated the peritoneum

URETHRAL CATHETERIZATION

Urethral catheterization is a valuable adjunct for any wound which may have involved the genitourinary organs The information gained from the passage of the catheter, sometimes with simultaneous rectal examination, aids in disclosing urethral wounds and obstruction (case 11) The gross and microscopic appearance of the urine aids in diagnosing injuries of the bladder and the kidneys Hematuria is evidence of damage to the genitourinary system, but its absence does not eliminate such damage (case 16) Blood in the first portion of the urine followed by clear urine is indicative of urethral injury (case 18)

CASE 18—In a 62 year old man there were hundreds of small wounds of the face, neck, chest, abdomen, legs and arms There were two fractures of the right tibia, one of the right radius and one of the fourth, and one of the fifth right metatarsal bones The abdomen was tender but not rigid Peristalsis was not audible Catheterized urine was bloody for the first few cubic centimeters and then clear This was demonstrated twice A small fragment was then shown to have lacerated the penile urethra At laparotomy the bladder and kidneys were demonstrated to be normal The intra-abdominal lesions were three lacerations of the ileum and a severe laceration of the transverse colon

When there remains doubt concerning a laceration of the bladder, the bladder may be emptied by catheter, after which a measured amount of sterile isotonic solution of sodium chloride is introduced to deter-

mine whether it can all be immediately withdrawn. If the patient does void clear urine freely and does not complain of pain or difficulty on micturition, catheterization usually is unnecessary.

AUSCULTATION OF THE ABDOMEN

In a recently wounded abdomen, the presence of peristalsis makes it unlikely that damage to the gastrointestinal tract or intra-abdominal hemorrhage has occurred. In case 19, although there was a large abdominal wound, the presence of active peristalsis aided in eliminating a diagnosis of intraperitoneal damage.

CASE 19—The patient was a 20 year old youth. There was a wound of the posterolateral surface of the upper third of the right thigh and an avulsed wound of the lower anterior abdominal wall in the midline. The abdomen was soft, and there was good peristalsis audible. Urine obtained by catheter was normal. The course of the projectile was demonstrated at operation. It had entered the thigh, coursed upward, medial to the femoral vessels, lacerated the right rectus muscle transversely and avulsed a portion of the abdominal wall. The bladder and peritoneum were exposed and found intact. The right spermatic cord was traumatized but not severed.

The absence of peristalsis points to intra-abdominal damage but not conclusively, for retroperitoneal and infraperitoneal injuries are usually accompanied by diminished bowel activity. The patient in case 20 presented a rigid, tender abdomen without peristalsis. This was demonstrated to be due to infraperitoneal hemorrhage and not to intraperitoneal injury.

CASE 20—In a 30 year old man the wound was in the midline of the abdominal wall 2 inches (5 cm) above the symphysis pubis. There were severe abdominal pain, tenderness and rigidity and no audible peristalsis. Rectal examination showed nothing abnormal. Urine obtained by catheter was normal. The roentgenogram showed a foreign body in the region of the superior ramus of the left pubic bone. A lower midline incision revealed a large hematoma of the prevesical and the left paravesical spaces due to severance of the obturator vessels. The peritoneum was pushed upward by the hematoma and was intact. The bladder was pushed to the right and was intact. The foreign body had severed the obturator vessels, then entered the femoral ring and lodged in the superior ramus of the left pubic bone.

ROENTGENOLOGIC EXAMINATION

The roentgenologic examination has been discussed in previous paragraphs. The chief value of the roentgenogram is to locate the foreign body so that the course of the missile may be plotted. As has been pointed out, this may be confusing if there are several missiles and several wounds. Foreign bodies which remain from former wounds, calcified lymph nodes and radiopaque substances in the intestines may be misleading. It is not always possible to locate the foreign body

accurately by roentgenogram, especially in wounds about the rectum. Occasionally only at operation is the exact position of the missile determined (case 12). In primary preoperative diagnosis, special roentgenologic technics are seldom advisable and, indeed, the condition of the wounded precludes much manipulation on the x-ray table. One has to be content with a frontal and a lateral view. Oblique projections may be ordered at times, but it is seldom worth while to return the patient to the roentgenologic department if one balances the added shock against the possible added information. Special genitourinary roentgenographic procedures find little place in this type of diagnosis.

Other roentgenologic observations which aid in plotting the courses of missiles are fractures, thoracic abnormalities (hemothorax, pneumothorax), subcutaneous emphysema, herniations through the diaphragm and gas under the diaphragm. Case 21 illustrates an interesting roentgenologic problem in differential diagnosis.

CASE 21.—In a 22 year old man there were two wounds of the left side of the chest, one in the eighth interspace in the anterior axillary line and one over the tenth rib posteriorly, 4 inches (10 cm) from the spine. The abdomen showed mild tenderness and rigidity in the left upper quadrant. The roentgenogram showed no foreign body. Except for a small portion of the apex, there was complete collapse of the left lung, with mediastinal shift to the right. There was a white border beneath the uncollapsed apex. No fluid was seen in the chest, though the left costophrenic angle was obliterated and the outline of the left side of the diaphragm was not clear. This, then, was a perforating wound of the left side of the chest, with air in the left thoracic cavity. If one considered the roentgenogram, three possibilities existed: 1. There was pneumothorax on the left side. 2. The air seen was due to a herniated stomach. 3. Some combination of the first two was present. The white band beneath the apex could have been pleura or stomach wall. At operation a thoracotomy was done, 8 inches (20 cm) of the left tenth rib being resected. (It had been comminuted by the exiting missile.) The thoracic cavity was filled with a hugely dilated stomach. The diaphragmatic laceration was large but tight about the stomach, as a badly lacerated spleen was also impacted in the hernial opening. By a nasal-stomach tube, enough air was finally removed from the stomach to allow the operation to be completed. (Surgical treatment consisted in splenectomy, ligation of the left gastroepiploic artery, repair of the lesser omentum, reduction of the abdominal contents, repair of the diaphragm and resection of 2 inches [5 cm] of severely lacerated lower lobe of the lung.) Some help in determining that the air in the left side of the chest was due to dilated stomach could have been obtained by repeating the roentgenologic examination after first aspirating through a stomach tube. A repetition of the roentgenologic examination was not done, as thoracotomy was decided on after the first roentgenogram had been seen.

THORACOABDOMINAL WOUNDS

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This subject is given a separate section, for certain diagnostic problems are peculiar to it. The wounds of entrance and exit may both be on the thoracic wall, and yet the missile may have traveled intra-

peritoneally part of the time. The diaphragm curves upward, so a missile may enter the chest, perforate the lung, enter the abdomen and then exit into the chest again through the diaphragm and reenter the lung. In its course through the abdomen, such a missile can easily damage spleen, stomach, colon or liver. Thus, at thoracotomy, two small perforations of the diaphragm are frequently encountered, one being the wound of entrance into, and one the wound of exit from, the abdomen. Occasionally the wound of entrance in thoracoabdominal wounds is from the abdomen into the chest. (In a series of 63 cases of thoracoabdominal wounds that I recently reviewed, in 8 the missiles had entered from the abdomen.)

As diaphragmatic perforation may be an indication for thoracotomy in thoracic wounds, it is especially important to diagnose it preoperatively. There are times when a thoracotomy is indicated largely to determine whether a diaphragmatic tear is present. All the steps in diagnosis previously enumerated must be considered. The course of the missile is suggestive in any penetrating or perforating wound of the lower half of the chest or in any penetrating thoracic wound in which the foreign body on the roentgenogram is so located that a line drawn from it to the wound of entrance touches any point on the diaphragm in expiration. One may be confused at times by a missile which is free in the pleural cavity and which shifts when the patient is moved. If the missile entered through the chest and is seen on the roentgenogram intra-abdominally or in the renal region, the diaphragm must be considered as perforated.

New problems in the appearance and the complaints of the wounded are introduced by disturbances of thoracic equilibrium. One symptom which actually points to disturbance of the digestive tract is dysphagia, and this may be due to an esophageal lesion anywhere along its course. The absence of dysphagia does not preclude a wound of the esophagus. During inspection of patients, at times a diaphragmatic tear may be seen through a sucking wound. When wounds permit the diaphragm to be seen prior to operation a diaphragmatic lesion must be suspected even if it is not in the field of vision.

The information obtained from palpation of the abdomen in cases of thoracoabdominal wounds is valuable and necessary but may be confusing and misleading at times. Two cases of thoracoabdominal wounds and lacerated spleens have been presented in which the observations on abdominal palpation were minimal (cases 14 and 21). Case 22 is also a case of thoracoabdominal wound and a lacerated spleen but the patient had pronounced abdominal rigidity.

CASE 22—In a 24 year old man there was one wound in the eighth left interspace in the posterior axillary line and one wound over the eleventh rib on the posterior left thoracic wall. There were severe tenderness and rigidity

in the left upper quadrant. Roentgenologic examination showed no foreign body, but there was fluid in the left side of the chest. A thoracotomy was done, 8 inches (20.3 cm) of the ninth rib being resected. Two holes were seen in the diaphragm, with omentum protruding through each. These holes were connected, and inspection of the abdomen transdiaphragmatically showed a lacerated spleen, necessitating splenectomy.

In auscultation of the chest in thoracoabdominal wounds, peristalsis may sometimes be heard if a traumatic hernia through the diaphragm is present. Roentgenologic examination has been discussed in previous paragraphs. It may be added that hemothorax occasionally is due to bleeding from some abdominal viscus through a diaphragmatic tear, and pneumothorax may be confused with air in the stomach (case 21).

SUMMARY

When the possibility exists of intra-abdominal or retroperitoneal or infraperitoneal injury in a wounded person a diagnostic routine of examination is suggested, which will enable the surgeon to determine what procedures are indicated.

The prime consideration is the plotting of the course of the missile. This is determined by the location of the wound or wounds and by certain roentgenologic observations. Inspection and palpation occasionally further aid in mapping the track of the projectile. Further diagnostic steps of importance are inspection of the wounds, abdominal and rectal palpation, urethral catheterization and roentgenologic examination. The general condition of the patient, his complaints and the findings at abdominal auscultation are less significant but still of value. The pitfalls of the various diagnostic steps have been described.

Having considered all the factors enumerated, one should be in a position to decide whether, and what type of, surgical treatment is indicated. Further, if the press of work is great, a priority number for surgical treatment may be assigned to the patient. One should be able to determine the most suitable approach (midline, subcostal, transdiaphragmatic or other). Occasionally, in spite of all preoperative attempts at accurate appraisal, the presence or absence of intra-abdominal damage is not established. In these cases, surgical exploration of the wound may complete the diagnosis but if uncertainty remains laparotomy is then mandatory.

The cases reported have been selected from the operative records of one general surgical team of an Auxiliary Surgical Group.

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CETYLPIRIDINIUM CHLORIDE AS A CUTANEOUS GERMICIDE IN MAJOR SURGERY

A Comparative Study

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THIS is a report of a study conducted on 575 patients in the surgical service of the Louisville General Hospital to determine the effectiveness of a relatively new germicide, cetylpyridinium chloride, as a cutaneous antiseptic. It was compared with other germicides used as cutaneous antiseptics in major surgical procedures for routine pre-operative preparation. The germicides used for comparison were selected as to type of compound and represented a mercurial, a combined cresol and mercurial and a cationic detergent.

OBJECTIVE OF THE STUDY

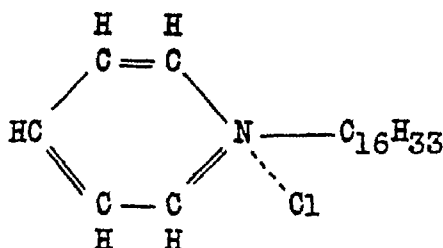
In conducting a study of the relative value of any chemical germicide to be used for cutaneous antiseptics immediately prior to operation, we recognized that the structure of the skin itself is such that its complete sterilization is impossible. The chief objective in preoperative preparation is actually a reduction in the number of pathogenic bacteria, or a quantitative and qualitative "degerming." Most of the published reports of studies of germicides used for cutaneous antiseptics have shown only the degree of degerming immediately after application of the germicide, or conclusions have been drawn regarding the value of the germicide from the incidence or the absence of postoperative infection.

Such studies may lead to fallacious interpretations for a number of reasons. The swab taken from the area to which a germicide has been applied may pick up enough of the germicide to effect bacteriostatic or

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germicidal action when transferred into the culture medium, provided there is not a sufficient quantity of medium to nullify this possibility. Postoperative infections are not a reliable index of the efficacy of a germicide.

In major surgical treatment the patient is subjected to anesthesia and operative procedures over varying periods, during which he is purposely kept warm. Consequently, there is sweating, and bacteria are "floated out" of the deeper structures of the skin, such as the crevices and the sweat and sebaceous glands, and these are potential contaminants provided the initial germicidal action of the antiseptic is not sustained over a long period. Therefore, study of immediate degerming action of a cutaneous antiseptic becomes merely an academic question, the duration of its action and the degree of its action when diluted with secretions of the skin are a true measure of its efficiency in major surgical procedures. Lovell¹ has pointed out the importance of the consideration of both the transient bacteria located on the surface of the skin and the resident bacteria in the deeper structures of the skin in studying cutaneous antiseptics by chemical germicides.



Structural formula of cetylpyridinium chloride

DESCRIPTION OF CETYLPYRIDINIUM CHLORIDE

Cetylpyridinium chloride is in the class of cationic detergents and is a quaternary ammonium compound with a single alkyl group. It has the structural formula shown in the chart. It will be noted that it does not contain in its molecular structure mercury or other heavy metal, phenol or cresol or the benzene ring. Not all cationic detergents have germicidal activity. Shelton and co-workers² found a definite correlation

1 Lovell, D. L. *Skin Bacteria Their Location with Reference to Skin Sterilization, Surg, Gynec & Obst* **80** 174-177, 1945.

2 Shelton, R. S., Van Campen, M. G., and Nisonger, L. L. *Correlation of Structure and Germicidal Activity of Certain Acyclic Quaternary Ammonium Salts*, Abstract of Papers, Ninety-Eighth Meeting of the American Chemical Society, Sept. 11-15, 1939. Shelton, R. S., Van Campen, M. G., Tilford, C. H., and Nisonger, L. L. *Correlation of Structure and Germicidal Activity of Some Quaternary Ammonium Salts Derived from Cyclic Amines*, Abstract of Papers, Ninety-Ninth Meeting of the American Chemical Society, April 8-12, 1940.

between structure and germicidal activity when studying various quaternary ammonium salts. They found, in studying pyridinium chlorides, that the cetyl ($C_{16}H_{33}$) pyridinium compounds were much more active than compounds containing the lauryl ($C_{12}H_{25}$), myristyl ($C_{14}H_{29}$) or stearyl ($C_{18}H_{37}$) groups.

Cetylpyridinium chloride is a surface-active agent, which gives it detergent, wetting and cleansing action and causes it to penetrate into crevices of the skin or wound as well as into the bacterial cell wall.

Blubaugh and co-workers³ studied the germicidal activity in vitro of cetylpyridinium chloride and compared it with that of well known germicides. The action was demonstrated to be bactericidal and not bacteriostatic, it was not selective but covered a broad bacterial spectrum, it was equal to or surpassed in germicidal activity all the other compounds studied.

Because the limited value of the phenol coefficient test in evaluating germicidal solutions has been recognized, results of in vivo studies have been published, correlating the germicidal activity of cetylpyridinium chloride in living tissue and its toxicity to tissues. Sarber⁴ demonstrated that cetylpyridinium chloride, in comparison with other cutaneous germicides, had a relatively high efficiency as to penetration and activity in the presence of tissue.

Green and Birkeland⁵ found that cetylpyridinium chloride was capable of reducing definitely the degree of infection in experimental *Staphylococcus aureus* infections of the living chorioallantoic membrane of the chick embryo. Solutions of iodine and chloroazodin had little or no therapeutic effect, phenol, sodium-4-nitro-5-hydroxymercurioorthocresol and sodium ethylmercurithiosalicylate had no demonstrable effect under the conditions of this test.

Green,⁶ using the chick embryo technic, studied the relationship of the therapeutic effectiveness, germicidal action and chemical structure of a number of cationic and anionic detergents. Cetylpyridinium chloride

3 Blubaugh, L. V., Botts, C. W., and Gerwe, E. G. A Study of the Germicidal Properties of Cetylpyridinium Chloride, *J. Bact.* **39** 51, 1940. Blubaugh, L. V., Gerwe, E. G., Botts, C. W., and Helwig, H. L. Further Observations on the Germicidal Activity of Cetylpyridinium Chloride, *J. Bact.* **41** 34, 1941.

4 Sarber, R. W. An in Vivo Method of the Evaluation of Germicidal Substances Used for Skin Disinfection, *J. Pharmacol. & Exper. Therap.* **75** 277-281, 1942.

5 Green, T. W., and Birkeland, J. M. The Use of the Chick Embryo in Evaluating Disinfectants, *Proc. Soc. Exper. Biol. & Med.* **51** 55-56, 1942. The Use of the Developing Chick Embryo as a Method of Testing the Antibacterial Effectiveness of Wound Disinfectants, *J. Infect. Dis.* **74** 33-36, 1944.

6 Green, T. W. The Action of Detergents on Staphylococcal Infections of the Chorio-Allantois of the Chick Embryo, *J. Infect. Dis.* **74** 37-40, 1944.

was found to be the most effective of all compounds studied, as shown by the number of embryos surviving with no evidence of infection

In all these *in vivo* studies, cetylpyridinium chloride was reported to be capable of acting in the presence of tissue and of preventing infection without serious harm to the tissues studied. The crucial test of a germicide for clinical use is a determination (for example, by the Welch-Hunter⁷ test) of the toxicity index, which is the ratio of the weakest dilution of the substance which is found germicidal and the strongest concentration harmless to tissue cells. It is obvious that a substance that has a toxicity index of 1 or more is toxic to tissue in germicidal concentration. Under the conditions of the Welch-Hunter toxicity test, cetylpyridinium chloride has a toxicity index of 0.49, indicating that it is twice as toxic to bacteria as to the tissue cells studied.

Warren and co-workers,⁸ in pharmacologic and toxicologic studies, determined the effect of local applications of cetylpyridinium chloride to the scarified skin of rabbits by means of gauze pads saturated with various concentrations of aqueous solutions of cetylpyridinium chloride held in place for twenty-four hours. Concentrations less than 1:250 had no irritating effect. Irrigation of experimental wounds with 1:1,000 solution did not interfere with healing.

Clarke⁹ compared the bactericidal action of cetylpyridinium chloride, tincture of iodine and a mercurial antiseptic on the intact skin and, at the same time, made patch tests with these substances to determine whether any irritation was produced. The 1:200 tincture and the 1:200 aqueous solution of cetylpyridinium chloride under the conditions of the test had a greater bactericidal efficiency and were free from irritating action. Iodine and the mercurial produced irritation in some of the cases studied.

Kramer and Sedwitz¹⁰ used cetylpyridinium chloride for preoperative preparation in combination with a special soapless technic for a large series of patients. No irritation was observed. The authors stated that there was no postoperative infection, but this alone is not an index of therapeutic efficacy. In the discussion of bacteriologic technic, no mention is made of a provision for the prevention of a transfer or a carry-over of the germicide by means of the swab from the prepared skin to the culture medium.

7. Welch, H., and Hunter, A. C. Method for Determining the Effect of Chemical Antisepsis on Phagocytosis, *Am J Pub Health* **30** 129-137, 1940.

8. Warren, M. R., Becker, T. J., Marsh, D. G., and Shelton, R. S. Pharmacological and Toxicological Studies on Cetylpyridinium Chloride, a New Germicide, *J Pharmacol & Exper Therap* **74** 401-408, 1942.

9. Clarke, G. E. Skin Sterilization with Cetylpyridinium Chloride, *Urol & Cutan Rev* **46** 245-246, 1942.

10. Kramer, G. B., and Sedwitz, S. H. Ceepryn. Clinical and Bacteriologic Studies, *Am J Surg* **63** 240-245, 1944.

Helmsworth and Hoxworth,¹¹ after extensive investigation of the use in major surgical procedures of various solutions and tinctures of cetylpyridinium chloride by various technics, found that a five to ten minute scrub of the operative field with a 1:100 aqueous solution provided the most effective quantitative degerming of the skin, as determined by cultures of swabs and of skin (removed as for a pinch graft). These authors pointed out the incompatibility of soap (an anionic detergent) and cetylpyridinium chloride (a cationic detergent). In this series, tincture of green soap is used in preparation of the operative site, but, theoretically at least, all traces of soap are removed by subsequent washing with water and ether.

CUTANEOUS ANTISEPTICS USED IN THE STUDY

The following antiseptics were used

- 1 Cetylpyridinium chloride, representing a cationic detergent with a single alkyl radical
- 2 Sodium ethylmercuri thiosalicylate (tincture of merthiolate 1:1,000), representing an organic mercurial compound
- 3 Mixture of equal parts of secondary amyltr cresols and ortho-hydroxyphenylmercuric chloride in 1:1,000 concentration (tincture of mercresin), representing a combination of cresolic and organic mercurial compounds
- 4 Mixture of high molecular alkyl dimethyl benzyl ammonium chlorides (tincture of zephiran chloride 1:1,000), representing a cationic detergent with several alkyl radicals

METHOD

In the method of study the aforementioned points relating to prevention of carry-over of the germicide to the bacteriologic medium, the penetration and duration of action of the germicide (quantitative degerming) and the selective bactericidal action (qualitative degerming) were taken into consideration.

In the study, the usual operating technic was employed on 575 consecutive patients who were suitable for the method used. Preparation of patients was done by all members of the surgical house staff, using a standard routine.

After the patient arrived in the operating room and the abdomen, leg, chest or other portion of the body had been exposed, a swab which had previously been moistened in isotonic solution of sodium chloride was swabbed across the right side of the exposure and then placed in 150 cc of the culture medium. A similar procedure was done on the left side of the exposure.

The skin was then washed with tincture of green soap, water and ether and the right side of the exposed skin painted with two coats of cetylpyridinium chloride and the left side of the exposed area painted with two coats of one of the other skin antiseptic agents.

¹¹ Helmsworth, J. A., and Hoxworth, P. I. A Clinical Appraisal of Cetylpyridinium Chloride as a Skin Antiseptic, *Surg., Gynec & Obst.* 80:473-478, 1945.

After the area was allowed to dry, a second set of swabs was taken, one from the right and one from the left side, and placed in 150 cc of broth medium. At the conclusion of the operative procedure, a third set of swabs was taken, one from the right and one from the left side, care being taken that if the field had become contaminated during operation the last set of swabs was taken well away from the area of contamination. These, also, were placed in 150 cc. of broth medium, and then the mediums were incubated at 37.5 C for seven days. Gram-stained slides were then studied for the bacteriologic flora present at the conclusion of incubation.

It should be noted that the effectiveness of the two germicides under study at any one time was determined against the bacterial flora of each individual patient. This constitutes a more closely controlled study than when tests for germicidal action are made on different series of patients, whose bacterial flora may vary as to pathogenicity and type.

The bacteriologic medium used was dextrose tryptose agar broth (B-63 Difco), and it will be noted that each swab was placed in 150 cc of the medium. It was shown by test that the amount of germicide picked up from the skin by the swab was diluted to inactive concentration both in regard to bactericidal and bacteriostatic action when placed in 150 cc of the broth. The use of the large amount of medium for each swab prevented any carry-over of the germicide in sufficient quantity to interfere with subsequent growth of the bacteria and with a true interpretation of the cultural results. It is now realized that this is extremely important, and procedures which do not take this into consideration may yield inaccurate and unreliable results.

Many organisms were encountered in the bacteriologic study, some of which were in all probability not pathogenic. Only the gram-positive diplococci, staphylococci, streptococci, gram-negative rods, actinomycetes and diphtheroids were classed as pathogenic contaminants. Gram-positive rods with spores, yeast-like organisms, tetrads and micrococci were disregarded in this report.

RESULTS

1 *Germicidal Efficiency at the Beginning and the End of Operation*—Cetylpyridinium Chloride and Merthiolate. This was used on a group of 200 patients. The primary swabs (before preparation) showed that 191 patients had organisms classed as pathogenic contaminants. After application of cetylpyridinium chloride, 117 (61.3 per cent) were negative. At the close of the operation, 90 (47.1 per cent) were negative, representing a 23.1 per cent loss of efficiency of this germicide during the course of the operation. After application of merthiolate 134 (70.2 per cent) were negative and at the close of the operation 73 (38.2 per cent), a 45.5 per cent loss in efficiency.

Cetylpyridinium Chloride and Mercresin. This was used on 177 patients. Before preparation 163 swabs showed positive contamination. After application of cetylpyridinium chloride, 90 (55.5 per cent) were negative and at the close of the operation 77 (47.2 per cent), a 14.4 per cent loss of efficiency during the operation. After application of mercresin, 112 (67.8 per cent) were negative and at the close of the operation 76 (46.6 per cent), a 32 per cent loss in efficiency.

Cetylpyridinium Chloride and Zephiran Chloride This was used on 198 patients Before preparation 156 primary swabs showed positive contamination After application of cetylpyridinium chloride 77 (49.4 per cent) were negative and at the close of the operation 57 (36.5 per cent), a 26.1 per cent loss in efficiency After application of zephiran chloride 73 (46.8 per cent) were negative and at the close of the operation 59 (37.8 per cent), a 19.2 per cent loss in efficiency

The results are shown in table 1

TABLE 1—Comparative Germicidal Effectiveness at Beginning and End of Operation

Tincture Used	Total Cases Studied	Number of Positive Swabs Before Preparation	Effectiveness		Loss of Germicidal Efficiency, %
			Immediately After Preparation, %	At Close of Operation, %	
Cetylpyridinium chloride	200	191	61.3	47.1	23.1
Merthiolate	200	191	70.2	38.2	45.5
Cetylpyridinium chloride	177	163	55.5	47.2	14.4
Mercresin	177	163	67.8	46.6	32.0
Cetylpyridinium chloride	198	156	49.4	36.5	26.1
Zephiran chloride	198	156	46.8	37.8	19.2

2 *Effect of Time Element on Germicidal Efficiency*—Cetylpyridinium Chloride and Merthiolate In operative procedures lasting one hour, cetylpyridinium chloride remained effective in 52 per cent of the cases and merthiolate in 42 per cent In those lasting one and one-half hours, cetylpyridinium chloride was effective in 45 per cent and merthiolate in 43 per cent In those lasting two hours, cetylpyridinium chloride was effective in 42 per cent and merthiolate in 48.5 per cent In those lasting two and one-half hours, cetylpyridinium chloride was effective in 29 per cent and merthiolate in 35 per cent In those lasting over two and one-half hours, cetylpyridinium chloride and merthiolate were both effective in 33 per cent There were too few procedures which lasted over two hours to give an accurate or reliable estimate of the effectiveness of any germicide used

Cetylpyridinium Chloride and Mercresin For procedures of various durations the effectiveness of the germicides was as follows one hour, cetylpyridinium chloride 47.5 per cent and mercresin 39 per cent, one and one-half hours, cetylpyridinium chloride 44 per cent and mercresin 50 per cent, two hours, cetylpyridinium chloride 48 per cent and mercresin 35 per cent, two and one-half hours, cetylpyridinium chloride 64 per cent and mercresin 50 per cent and over two and one-half hours, cetylpyridinium chloride 50 per cent and mercresin 0 per cent

Cetylpyridinium Chloride and Zephiran Chloride For procedures of various durations the per cent effectiveness of these two germicides is as follows one hour, cetylpyridinium chloride 34 per cent and zephiran

TABLE 2—*Comparative Study in Relation to Time*

		Period of Application																			
		Application, 1 Hr				Application, 1½ Hr				Application, 2 Hr				Application, 2½ Hr				Application, Over 2½ Hr			
		Con tamined, No		Not Contaminated %		Con tamined, No		Not Contaminated %		Con tamined, No		Not Contaminated %		Con tamined, No		Not Contaminated %		Con tamined, No		Not Contaminated %	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Total Cases		37	41	62.0	27	22	45	15	11	42.0	12	5	29	2	1	33					
Antiseptic Agent		173	33	42.3	23	21	43	10	10	35.5	11	6	33	2	1	33					
Cetylpyridinium chloride		173	45																		
Mercholate		151	42	38	47.5	18	14	44	12	48.0	5	0	64	1	1	50					
Cetylpyridinium chloride		151	49	31	39.0	16	10	50	8	35.0	7	7	50	2	0	0					
Mercresin		108	64	33	34.0	18	12	40	9	21.0	6	4	40	2	5	71					
Cetylpyridinium chloride		163	65	32	33.0	19	11	37	7	20.0	8	2	20	3	4	57					
Zephiran chloride																					

chloride 33 per cent, one and one-half hours, cetylpyridinium chloride 40 per cent and zephiran chloride 37 per cent, two hours, cetylpyridinium chloride 21 per cent and zephiran chloride 29 per cent, two and one-half hours, cetylpyridinium chloride 40 per cent and zephiran chloride 20 per cent, and over two and one-half hours, cetylpyridinium chloride 71 per cent and zephiran chloride 57 per cent

Table 2 presents these results and gives the number of cases in each group

3 *Comparison of Effectiveness Against Specific Organisms*—Cetylpyridinium Chloride and Merthiolate When staphylococci were present in the culture from the primary swab, 67 per cent were rendered negative by cetylpyridinium chloride and 73 per cent by merthiolate Against diphtheroids, cetylpyridinium chloride was 65 per cent effective and merthiolate 85 per cent Against aerobic streptococci the per cent

TABLE 3—*Comparison Chart of Cetylpyridinium Chloride and Other Antiseptic Agents in Effectiveness Against Specific Organisms**

	Staphylococci *				Diphtheroids *				Streptococci *			
	1	2	3	4	1	2	3	4	1	2	3	4
Cetylpyridinium chloride	186	125	61	67%	52	34	18	65%	40	33	2	95%
Merthiolate	185	134	51	73%	52	44	8	85%	30	29	1	97%
Cetylpyridinium chloride	110	110	47	70%	43	43	15	74%	20	20	1	95%
Mercresin	118	118	42	74%	48	48	11	81%	15	15	0	100%
Cetylpyridinium chloride	180	105	75	58%	54	34	20	63%	23	21	2	91%
Zephiran chloride	187	99	88	53%	54	35	19	65%	19	19	0	100%

* Explanation of data In column 1 are listed the total number of patients infected In column 2 are listed the number of patients in whom the organism was absent after application of the germicide In column 3 are given the number of patients in whom the organism was present after application of the germicide In column 4 are given the percentages of effectiveness of the germicide

effectiveness of cetylpyridinium chloride was 95 per cent and merthiolate 97 per cent

Cetylpyridinium Chloride and Mercresin Against staphylococci, cetylpyridinium chloride was 70 per cent effective and mercresin 74 per cent Against diphtheroids, cetylpyridinium chloride was 74 per cent effective and mercresin 81 per cent Against aerobic streptococci, cetylpyridinium chloride was 95 per cent effective and mercresin 100 per cent

Cetylpyridinium Chloride and Zephiran Chloride Against staphylococci cetylpyridinium chloride was 58 per cent effective and zephiran chloride 53 per cent, against diphtheroids, cetylpyridinium chloride 63 per cent and zephiran chloride 65 per cent, against streptococci, cetylpyridinium chloride 91 per cent and zephiran chloride 100 per cent

These results, including the number of cases involved, are shown in table 3

COMMENT

Before the statistics are discussed, it is of interest to note that there was an average of 30 per cent skin contaminations at the time of operation. One might suspect that there would be a high incidence of postoperative infection. This has not been true, however, in this hospital, and the statistics compare favorably with those of other hospitals of similar size. As stated in the introduction, the presence or absence of postoperative infection is not, per se, an index of the efficacy of the skin antiseptic used in immediate preoperative preparation.

Although no anaerobic organisms were isolated, they were undoubtedly present and probably could have been demonstrated had additional laboratory facilities been available. The organisms listed as contaminants may or may not have been pathogenic, but the laboratory facilities necessary to determine this and to type the organisms were not available. It is well known that any culture of mixed organisms when incubated over a seven day period tends to become a pure culture of the predominant organism. The staphylococcal organism, particularly, is capable of crowding out less hardy organisms, and it may be that the scarcity of organisms culturable after the application of the various cutaneous antiseptics is due in part to this factor, rather than to the germicidal effect of the agent used.

In reviewing the first portion of the study, which evaluates the maintenance of germicidal effectiveness throughout the operation, the statistics indicate that 1:1,000 tincture of cetylpyridinium chloride retains its initial effectiveness in a greater per cent of cases than does the mercurial or the cresolic-mercurial antiseptic. When compared with another cationic detergent germicide, the results were not significantly different.

In the second portion of the study, the time element was plotted against the degree of effectiveness. It will be noted that, while the initial effectiveness of cetylpyridinium chloride was slightly less than that of the mercurials, after the lapse of periods of one hour and two hours its effectiveness was slightly greater. The statistics after two hours are in all probability unreliable, since relatively few operations lasted over two hours. Again, there was no significant difference in the two cationic agents.

The third portion of the study reveals that there is no material difference in the effectiveness of the various germicides studied against staphylococci and aerobic streptococci. Against diphtheroids, cetylpyridinium chloride appeared to be less active than merthiolate but had approximately the same activity as the other compounds studied.

SUMMARY

A study of cetylpyridinium chloride shows that it is detergent and germicidal, both in vitro and in vivo, and it has a favorable toxicity index. Clinically, in therapeutic concentrations it is relatively non-irritating. The germicidal efficiency of a 1:1,000 tincture of cetylpyridinium chloride as a cutaneous germicide for preoperative preparation for major surgical procedures has been compared with that of three other agents, representing a mercurial, a combined cresolic-mercurial preparation and another cationic detergent. In each case, the two germicides under test at any one time were applied to the same person. Due regard was taken to prevent distortion of cultural statistics by a transfer of the germicide by the swab from the skin to the culture. Germicidal effectiveness of the various antiseptics used was determined at the beginning and the end of the operation, showing the degree and duration of the germicidal action and the per cent loss in efficiency in relation to elapsed time. The activity of these antiseptics against specific organisms was computed.

CONCLUSIONS

- 1 The usual preoperative preparation technic including the use of various cutaneous antiseptics proved to be not over 70 per cent effective in ridding the operative field of culturable organisms.
- 2 Those antiseptics having a detergent or wetting action definitely retained their initial effectiveness for longer periods than did the mercurial and cresolic-mercurial compounds.
- 3 All antiseptics used were definitely effective against aerobic streptococci, somewhat less effective against diphtheroid and considerably less effective against staphylococcal organisms.
- 4 Cetylpyridinium chloride in the form of a 1:1,000 tincture compared favorably in all studies with other cutaneous antiseptics used.

SYNTHETIC ADHESIVES IN THE TREATMENT OF WOUNDS OF THE LIVER AND OTHER SURGICAL CONDITIONS

A Preliminary Report

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IN SEPTEMBER 1943, I conceived the idea of attempting to control hemorrhage in abdominal viscera and elsewhere by the application of the so-called commercial Scotch tape

The adhesiveness of this material in extirpated chicken organs was established in preliminary experiments In dead animals, severed nerves and arteries were also held together by this substance, as were cut skin edges

EXPERIMENTAL STUDIES

Rabbits 3 to 5 months old were selected for the *in vivo* experiments To date, 17 rabbits have been operated on, with 1 death Eleven additional rabbits comprised a control group Of these, 8 rabbits died in the first twenty-four hours and 3 lived

In each operation, a large pie-shaped section of the rabbit liver was completely extirpated No attempt was made to control the profuse bleeding with sutures or packs or by bringing together the sides of the wound in the liver Instead, the resulting hiatus was covered only by an envelope of Scotch tape Various technics were tried The one found most satisfactory consisted in covering the upper and the lower surfaces of the aperture in the liver with two strips of tape These strips were brought together at the edge of the liver and the excess tape material cut away The resulting Scotch tape envelope, adhering to the intact liver on all sides, formed a leak-proof nidus for the formation of the primary clot Sponging with gauze and light digital pressure on the liver above the wound controlled the bleeding sufficiently to insure the adhesion of the tape Different types of tapes showed varying degrees of adhesiveness Undoubtedly the present technic can be much improved A minor irritation is the tendency of the tape to adhere to the gauze and to rubber gloves In all animals, final adherence of the tape to the liver was accomplished Closure of the rabbit's abdomen was accomplished with sutures, with Scotch tape layered over the skin

Ether was the anesthetic used Operating facilities in these experiments were extremely crude, so that surgical asepsis could not be obtained No attempt was made to sterilize the tape itself In the earlier experiments, the instruments were not sterilized, this doubtless being the cause of the 1 death from peritonitis in the series

The tape retained its adhesiveness in climatic conditions varying from the dryness of Texas to the moist heat of the New Guinea jungle

Presented before the Society for Experimental Biology and Medicine, Rocky Mountain Branch, at the University of Utah, Salt Lake City, May 26, 1945

After the closure of the abdomen, with the gap in the liver enveloped only by the tape, the rabbits were returned to their cages for further study. Autopsies were performed on all animals at periods of from two to five weeks following the extirpation of the section of liver. In these experiments, the wound in the liver was selected as representing a type of hemorrhage extremely difficult to control.

The animals were killed by large inhalations of ether and the abdomens reopened. Particular attention was directed to the absence or presence of blood or adhesions within the abdominal cavity. Sections were prepared, and a minute study of the healed portions of the liver was made and also of the portion not operated on.

In the 11 rabbits used as controls, small sections of the liver were extirpated and the abdomen closed, with the raw edges of the cut liver surface uncovered by any material.

SCOTCH TAPE

The ordinary commercial Scotch tape is made of three layers (1) a backing, usually cellophane, (2) a filler or a binder, of rope stock, and (3) an adhesive face of crude rubber or some synthetic substitute. On the first 3 rabbits, the ordinary commercial Scotch tape was utilized.

At my suggestion, the Minnesota Mining and Manufacturing Company, the makers of Scotch tape, developed new and experimental synthetic combinations for further investigation on animals.

Experiments by me, corroborated by separate investigations of the Naval Medical Research Institute, have demonstrated that types of Scotch tape may be sterilized by autoclaving at 15 pounds (6.8 Kg.) of pressure for fifteen minutes without impairment of any essential quality. The question of chemical sterilization is also under consideration.

To date, eleven different synthetic combinations of Scotch tape have been manufactured for these experiments. The backings for these combinations consist of either (1) cellophane or (2) polyvinyl alcohol. All but one experimental sample contain rope stock paper filler. Various adhesives, such as crude rubber, polyisobutylene, Buna S and synthetic resin adhesives, have been incorporated into the facing surface of the tape.

EXPERIMENTS ON RATS

Small pieces of the various Scotch tapes were inserted intraperitoneally in 2 month old white rats, the abdomen closed and the animals returned to their cages. Thirty days later the rats were killed. The intraperitoneal reaction and the extent of the absorption of the different tapes were studied. Results are given in table 1.

All animals except rabbit 2 resumed their normal diet and mode of life on the second postoperative day. In all animals bleeding from the liver was completely controlled, and no evidence of intra-abdominal hemorrhage was found.

Rabbit 2 died on the fourth day after the operation, of a generalized peritonitis. This undoubtedly was the result of not sterilizing instru-

ments, which in the operations on the first 2 rabbits were only dipped in alcohol. There was, however, no evidence of intra-abdominal bleeding.

Under ether anesthesia, the first rabbit was reoperated on on the twenty-first day. No intra-abdominal adhesions were noted, and no evidence was found of the Scotch tape on the surface of the liver. As a matter of fact, the operative scar on the liver was so obscure as to necessitate killing the animal and completely removing the liver.

The liver was incised at the site of the previous operation and a section removed for microscopic study. A small sterile abscess was found within the liver itself, in which were small particles of the Scotch tape incompletely absorbed. The abscess was localized and completely

TABLE 1—*Results of Experiments on Rabbits*

Rabbit	Type of Tape	Result
1	Cellophane, rope stock, crude rubber	Uneventful recovery. Killed 21 days postoperatively
2	Cellophane, rope stock, crude rubber	Died on fourth postoperative day of diffuse peritonitis
3	Cellophane, rope stock, crude rubber	Uneventful recovery, killed at 21 days
4	Acetate fiber, rope stock, polyisobutylene	Uneventful recovery, killed at 21 days
5	Acetate fiber, rope stock, polyisobutylene	Uneventful recovery, killed at 28 days
6	Cellophane, rope stock, polyisobutylene	Uneventful recovery. Killed 28 days postoperatively
7	Cellophane, rope stock, Buna S	Uneventful recovery, killed at 25 days
8	Cellophane, rope stock, synthetic resins	Uneventful recovery. Killed at 28 days
9	Polyvinyl alcohol, rope stock, polyisobutylene	Uneventful recovery, killed at 7 days
10	Polyvinyl alcohol, rope stock, Buna S	Uneventful recovery, killed at 7 days
11	Polyvinyl alcohol, rope stock, synthetic resins	Uneventful recovery, killed at 7 days
12	Polyvinyl alcohol, rope stock, crude rubber	Uneventful recovery. Killed at 7 days
13	Polyvinyl alcohol, rope stock, synthetic resins	Uneventful recovery, killed at 14 days
14	Polyvinyl alcohol, rope stock, synthetic resins	Uneventful recovery, killed at 21 days
15	Polyvinyl alcohol, rope stock, synthetic resins	Uneventful recovery, killed at 28 days
16	Polyvinyl alcohol, rope stock, synthetic resins	Uneventful recovery, killed at 30 days
17	Polyvinyl alcohol, rope stock, crude rubber	Uneventful recovery, killed at 28 days

encapsulated and apparently had caused the animal no harm. Scar and parenchymal tissue from the liver had grown over and engulfed the tape within the organ.

Microscopic sections from this area revealed surprisingly little severe tissue reaction. Laterally, the scar faded out into apparently normal liver parenchyma.

Within the sterile hepatic abscess, there was no evidence of prolonged bleeding. Microscopic sections demonstrated a rather definite line of demarcation at which the bleeding had apparently stopped. The predominant zones were (1) normal liver parenchyma, (2) red blood cells, (3) polymorphonuclear leukocytes and foreign body substance, and (4) fibrous scar tissue in which liver parenchyma cells were also involved.

More than half a lobe of the liver was removed in rabbit 3, and bleeding was controlled only with considerable difficulty. That this rabbit lived at all was considered remarkable, as it was practically moribund following the shock of the removal of so large an amount of liver. However, on the fourth day it had fully recovered. The conditions observed at autopsy on the twenty-first day were similar to those in rabbit 1, except that for some reason the resulting abscess and encapsulation were nearer the surface of the liver.

Rabbit 4, treated with tape containing acetate fiber and polyisobutylene, when examined at autopsy at twenty-one days showed a small encapsulated intrahepatic abscess, a culture from which gave a growth of *Staphylococcus albus*. The same organism was obtained from immersing the Scotch tape in broth.

Rabbit 5, in which tape containing acetate fiber and polyisobutylene was used, on which autopsy was performed at twenty-eight days showed cheesy material within the small foreign body capsule and particles of the incompletely absorbed tape.

Killed at the end of four weeks, rabbit 6, treated with tape containing polyisobutylene adhesive, rabbit 7, treated with tape containing Buna S, and rabbit 8, treated with tape containing synthetic resins (all three tapes had the cellophane and the rope stock backing), showed slightly more, but still incomplete, absorption of the tapes within the liver. In all 3, the resulting foreign body encapsulation within the liver contained soft cheesy material. In rabbits 6 and 7, some coils of the intestines adhered to the wound in the liver.

It was then felt that a substance more absorbable than cellophane must be used. Numerous types of backings and adhesive facings were considered. In the Scotch tape used on the livers of rabbits 9 to 17 polyvinyl alcohol film was used (together with rope stock paper filler) instead of cellophane.

Examined at autopsy at the end of one week, the livers of rabbits 9, 10, 11 and 12 showed more complete absorption of the polyvinyl alcohol tape and less tissue reaction than was evidenced at the end of one month in the livers treated with the cellophane Scotch tape.

Rabbit 11, in which the tape containing polyvinyl alcohol with synthetic resins adhesive was used, showed by far the greatest absorption of tape by the liver, together with the least tissue reaction. Next in line on the basis of these two qualities were rabbits 9 and 12, treated with the polyvinyl alcohol, polyisobutylene and crude rubber tapes. Of the four polyvinyl alcohol film tapes used in these 4 rabbits, the Buna S adhesive (used in rabbit 9) showed the least absorption and the greatest amount of tissue reaction.

In attaching these tapes over the wound in the liver bleeding was most readily controlled with the polyvinyl alcohol and synthetic resin

tape The adhesiveness of Buna S to the liver was less than that of either the polyisobutylene or the crude tapes This difficulty was also encountered in the cellophane and Buna S adhesive (used in rabbit 7)

Rabbits 13, 14, 15 and 16 were treated with polyvinyl alcohol and synthetic resin tapes and killed at two, three, four and five weeks respectively In each of these animals, over the filled-in hiatus in the liver, was a small encapsulated cystic mass containing cheesy material No sections of the Scotch tape could be distinguished as such in any of the livers The caseous capsule, about $\frac{1}{4}$ inch (0.65 cm) in diameter in rabbit 13 to $\frac{3}{8}$ inch (1 cm) in rabbits 15 and 16, resulted, it was felt, from the incompletely absorbed rope stock paper filler of the Scotch tape

Tiny particles of unabsorbed tape were observed in the liver of rabbit 17, treated with tape containing polyvinyl alcohol and crude rubber adhesive, which was examined at autopsy at one month Tissue reaction was slightly more pronounced than in the liver of rabbit 15, also killed at one month but treated with a polyvinyl alcohol and synthetic resins tape

Two attempts were made to control the bleeding from the liver with a special tape composed of polyvinyl alcohol film directly on a nonrubber adhesive, with the elimination of the rope stock filler This tape was extremely stretchy and had been injured by exposure to the tropic heat and moisture, hence other types of tape had to be substituted for controlling the bleeding from the liver

In all animals except rabbit 2, the peritoneum itself showed little reaction In rabbits 4, 5, 6, 7 and 8, there was some adherence of the surrounding intestines to the wound in the liver In all animals, the other abdominal viscera were normal, as were the lobes of the liver not operated on, normal liver parenchyma was found a short distance from the operative scar

RABBITS USED AS CONTROLS

Eight of the 11 control rabbits died within twelve hours of intraperitoneal hemorrhage The remaining 3 rabbits recovered and were alive at the end of two weeks following the liver extirpation These 3 animals, the first of the controls operated on, had relatively small sections of liver removed However, the resistance of rabbits to both trauma and infection is noteworthy, as evidenced by the survival of these 3 animals as well as the 16 in which unsterilized tape was intraperitoneally implanted (table 2)

The four most satisfactory tapes on the basis of intraperitoneal absorption in rats are (1) polyvinyl alcohol and nonrubber adhesive (without rope stock filler), (2) polyvinyl alcohol, rope stock and

synthetic resins, (3) polyvinyl alcohol, rope stock and crude rubber, and (4) polyvinyl alcohol, rope stock and polyisobutylene

STERILIZATION OF SCOTCH TAPES

Each of the samples tested was immersed in a sterile test tube infusion of brain-heart broth and autoclaved for twenty minutes at 120 C

TABLE 2—*Intraperitoneal Absorption in Rats*

Peritoneal reaction of white rats examined at autopsy thirty days after insertion of small pieces of various types of Scotch tapes

Rat	Tape	Intraperitoneal Reaction
1	Cellophane film, rope stock, polyisobutylene adhesive	Localized abscess, considerable tissue reaction and intestinal adhesions, tape incompletely absorbed
2	Polyvinyl alcohol, rope stock polyisobutylene adhesive	Slight tissue reaction, no adhesions tape absorbed
3	Polyvinyl alcohol, rope stock, Buna S adhesive	Slight tissue reaction, no adhesions tape absorbed
4	Cellophane, rope stock, synthetic resins adhesive	Some tissue reaction, no visible tape or adhesions
5	Polyvinyl alcohol, rope stock, synthetic resins adhesive	No tissue reaction, no adhesions, no tape
6	Polyvinyl alcohol, rope stock, crude rubber adhesive	No tissue reaction, no adhesions, no tape
7	Acetate film rope stock, polyisobutylene adhesive	Considerable tissue reaction few adhesions only partial tape absorption
8	Polyvinyl alcohol, polyisobutylene (without rope stock filler)	No reaction no adhesions no tape

No growth was obtained in any of the test tubes at the end of forty-eight hours

Another group of samples were placed in dry test tubes and autoclaved under similar conditions. The various tapes were then examined for adhesiveness, elasticity and resultant condition (table 3)

All tapes were capable of complete bacteriologic sterilization. The tapes most satisfactorily retaining their adhesiveness, elasticity and

TABLE 3—*Results of Autoclaving Tapes*

Tape	Adhesiveness	Elasticity	Condition
Cellophane rope stock polyisobutylene	Good	Good	Good
Polyvinyl alcohol rope stock polyisobutylene	Good	Good	Good
Cellophane, rope stock Buna S	Poor	Poor	Fair
Polyvinyl alcohol rope stock Buna S	Fair	Fair	Fair
Cellophane, rope stock synthetic resins	Very good	Very good	Very good
Polyvinyl alcohol, rope stock, synthetic resins	Excellent	Very good	Good
Cellophane, rope stock crude rubber	Very good	Very good	Good
Polyvinyl alcohol rope stock crude rubber	Very good	Very good	Good
Polyvinyl alcohol, polyisobutylene (without rope stock filler)	Poor	Fair	Melted

structural condition after autoclaving were in order of their effectiveness (1) polyvinyl alcohol, rope stock and synthetic resins, (2) polyvinyl alcohol, rope stock and crude rubber and (3) polyvinyl alcohol rope stock and polyisobutylene

COMMENT

These experiments demonstrate the feasibility of controlling visceral bleeding within the abdomen by the use of certain adhesives mounted on a thin film of cellophane or polyvinyl alcohol

Admittedly, 17 rabbits is too small a series on which to base definite conclusions. Yet the fact that 16 of 17 of these rabbits made normal recoveries, is of great significance, particularly in view of the operative technic used—extirpation of sizable portions of the liver with no approximation of the sides of the gap or attempt to control hemorrhage other than enveloping the wound between an upper and a lower layer of Scotch tape.

The rabbit's well known resistance to infection is also acknowledged. This was essential, inasmuch as unsterilized tape was used in all instances.

The death of the 1 animal of generalized peritonitis on the fourth day could be due to the unsterilized tape or instruments or to the generally inadequate operative technic.

Of the control group of 11 animals, 4 of the rabbits died within five hours after the operation and 4 survived almost twelve hours. The remaining 3 may be said to have recovered, demonstrating an intrinsic quality of the rabbit liver itself in its limitation of bleeding.

But that no treated rabbit died of hemorrhage and that no evidence of intraperitoneal bleeding was found in any of the animals are of primary importance and justify further investigations for a tape structure meeting surgical qualifications.

It was recognized after the pathologic examination of the liver of the first rabbit that, while the ordinary Scotch tape of commerce might control bleeding, it was unsuitable for use in human beings, without modification. Furthermore, it was clear that certain synthesis and trial of such tapes must be carried on.

- 1 The tape must be prepared and packaged sterilely or be capable of sterilization.

- 2 The tape must adhere to the wound and control bleeding.

- 3 The minimum of tissue reaction must result.

- 4 The tape itself must be completely absorbed by the tissues within six weeks. This criterion is of equal importance with the control of bleeding.

The laboratories of the Minnesota Mining and Manufacturing Company, at my suggestions, have produced the experimental tapes for these studies. Several new synthetic combinations, not included in this report, are available for further animal investigation.

I Sterilization—By autoclaving under pressure, it is possible to render any of these tapes absolutely sterile. While certain of these tapes retain most of their essential qualities, others (particularly those with the polyvinyl alcohol and the polyisobutylene without the rope stock filler) are completely dissolved by the autoclave. Vice Admiral Ross T. McIntyre has reported that the Naval Medical Research Institute finds no deterioration of the adhesive qualities of the Scotch acetate-polyisobutylene tape after autoclaving.

Nevertheless, it is believed that chemical sterilization may be found more advantageous. A new experimental tape is being produced, incorporating phenylmercuric stearate as a germicide.

Sterile packaging presents no undue problems. A sterile tape can be produced either by means of autoclaving or by means of chemicals.

II Adhesiveness and Control of Bleeding—Of the adhesives tested in these experiments, the synthetic resins, from the standpoint both of adhesiveness and of control of bleeding, proved the most satisfactory. Acrylic esters are the chief components of the synthetic resin adhesive.

Next in point of effectiveness were crude rubber and polyisobutylene (known as Vistonex).

Buna S is the least satisfactory with regard to adhesiveness and control of hemorrhage.

The chief difficulty of the operation usually ensues in controlling bleeding of the liver sufficiently to insure adherence of the tape. Different techniques have been and are being tried. But in all instances the tape was made to adhere without too great difficulty.

It was noted, however, that the bleeding from the liver was much more readily controlled when synthetic resin adhesives were applied. This was noticeable whenever this adhesive was used, regardless of a cellophane or polyvinyl backing.

This striking antihemorrhagic quality of the highly polymerized synthetic resins requires further investigation. Some of the complex chemicals used in the synthetic resins are

Polyvinyl alcohol	$(\text{CH}_2\text{CHOH})_x$
Methyl methacrylate	$\text{CH}_2-\text{C}(\text{CH}_3\text{COOCH}_3)$, polymerized
Casein-formaldehyde	Condensation product, structure uncertain
Glyptal resins	$\text{C}_6\text{H}_4(\text{COOCH}_2)\cdot\text{CHOH}$, polymerized
Ureac-formaldehyde	$\text{HOCH}_2\text{NH CO NH CH}_2\text{OH}$, can be used as solution of solid resins, or liquid ("A" stage) resins can be used

Also to be considered as possible antihemorrhagic agents are the so-called plasticizers, used in resin adhesives to eliminate excessive brittleness. These substances also bear study.

Dimethyl phthalate	$C_6H_4(COOCH_3)_2$
Dibutyl phthalate	$C_6H_4(COOC_2H_5)_2$
Tricresyl phosphate	$(C_6H_4CH_3O)_3PO_4$

Another possibility is Hexamethylenetetramine (Urotropin)

III Tissue Reaction—It is difficult to ascertain precisely what chemicals or part of the Scotch tapes cause the reaction of the surrounding tissue. Cellophane, however, caused more reaction than did the polyvinyl alcohol film. Apparently, of the adhesives the synthetic resins were the least irritating. It was also felt that the rope stock paper filler incorporated into the tape was an important source of tissue irritation.

IV Absorbability—Of the Scotch tapes used in these experiments, the tape made of polyvinyl alcohol film backing, rope stock paper filler and synthetic resins adhesive proved the most readily absorbed by the liver. This tape does not, however, meet specifications necessary for use in human patients.

While a few weeks following the original operation the intrahepatic abscess may not be found, a caseous semisolid mass is usually contained within the surrounding fibrous wound capsule. Even though apparently causing no damage to the perfect recovery of the rabbit, search for a more completely absorbable tape must continue.

Polyvinyl alcohol is definitely superior to cellophane and acetate fiber as a film backing capable of being absorbed by the liver. The polyvinyl alcohol film, as such, was not found in the resulting scar in the liver, as was the case with particles of cellophane and acetate fiber.

It cannot be absolutely stated, but these studies indicate, that the synthetic resins adhesive is also capable of a pronounced degree of absorption by the liver. This is the case, but to a lesser degree, with polyisobutylene, crude rubber and Buna S.

Apparently these tapes are more readily absorbed intraperitoneally than within the liver parenchyma itself. For while the tapes of polyvinyl alcohol, rope stock and synthetic resins, of polyvinyl alcohol rope stock and crude rubber and of polyvinyl alcohol, rope stock and polyisobutylene were completely absorbed when inserted intraperitoneally in the rat, caseous material remained when these tapes were found within the rabbit's liver.

Some of this residual material may result from infection and use of unsterilized tapes.

However, it is believed that this caseous matter is not polyvinyl alcohol or synthetic resins but a result of the breakdown of the rope stock paper filler.

Early in these experiments, the importance of eliminating the rope stock paper binder was recognized. The first experimental polyvinyl

alcohol and polyisobutylene tape produced without the paper filler was too flimsy and thin to be satisfactory

The laboratories of the Minnesota Mining and Manufacturing Company have recently succeeded in producing such a tape, the direct coating of a synthetic resin adhesive onto a polyvinyl alcohol film backing, without using a rope stock filler. Also incorporated in the tape is phenylmercuric stearate as a germicide.

Experiments on dogs and rabbits with this newly synthesized tape were conducted, utilizing the laboratories of the University of Utah School of Medicine and the University of Oregon Medical School. The results to date have shown this tape to more closely approximate the requirements essential to an ideal synthetic adhesive in the treatment of wounds and bleeding.

SURGICAL POSSIBILITIES

The development of a completely absorbable tape, capable of adhering to tissue and controlling bleeding, will offer a new technic to the field of surgery.

The possibilities of a perfected tape for war or general surgical procedures are many.

In this preliminary report, hepatic wounds were selected as presenting a type of bleeding most difficult to control. A perfected absorbable tape should be useful in controlling bleeding anywhere within the body. For bleeding on the surface of the body, of course, an absorbable tape is not essential. In plastic surgery this tape should prove of great value.

An oral surgeon has suggested the immediate use of this tape in operations on a cleft palate. However, until further research has been completed, the clinical use of this tape on human beings cannot be recommended.

Other uses for which technics may be developed are repair of nerves, tendons and blood vessels, treatment in thoracic, brain, gastrointestinal, gynecologic, urologic and orthopedic surgical procedures, and rapid, effective treatment of war wounds.

CONCLUSIONS

The application of plastic adhesives, similar to the Scotch tape of commerce, is effective in controlling bleeding and causing healing in the livers of rabbits in which sizable sections have been completely removed.

Of the various experimental tapes used, a polyvinyl alcohol backing and a synthetic resin adhesive held together by rope stock proved the most effective and caused the least tissue reaction. This chemical

combination, except for a caseous residue at the end of four weeks was apparently absorbed within the liver. Incomplete absorption of the rope stock paper, it is felt, causes this residue.

A new polyvinyl alcohol and synthetic resins tape eliminating this rope stock but incorporating a germicide, has just been produced. Further experimentation in animals with this and other tapes must be completed with continued sterilization studies before clinical application can be considered.

The possibilities are bright for the perfection of this tape and technic.

SUMMARY

1 Seventeen rabbits had sections of their livers removed and the gap covered above and below by an envelope of a variety of Scotch tape. Sixteen of the animals made complete and normal recoveries, being killed at the end of from one to five weeks for the study of their livers. One rabbit died of peritonitis on the fourth postoperative day.

2 In all animals, bleeding from the wound in the liver was controlled by the envelope of Scotch tape, with no evidence of intra-abdominal hemorrhage. A small localized encapsulated abscess or a caseous residue surrounded by fibrous tissue was the usual pathologic finding.

3 Eleven rabbits were operated on to serve as a control group, the abdomen being closed with no covering over the cut edges of the extirpated liver. Three of the animals with the least amount of liver cut away, survived. The other 8 animals died of an intraperitoneal hemorrhage within twelve hours.

4 Various types of specially synthesized tapes were used in these experiments. Though not completely absorbed, a tape composed of (1) a backing of polyvinyl alcohol film, (2) a rope stock paper filler, and (3) a synthetic resins adhesive proved the most satisfactory. A new tape eliminating the paper and incorporating a germicide, is now available for further research.

5 In mice, small pieces of tapes made of polyvinyl alcohol and synthetic resins, polyvinyl alcohol and polyisobutylene and polyvinyl alcohol and crude rubber inserted intraperitoneally were completely absorbed at the end of one month. No tissue reaction was noted, even though rope stock was part of the tape.

6 Some substance in the synthetic resins apparently exerts a pronounced hemostatic action, as this adhesive controlled bleeding the most readily.

7 Further animal experimentation and sterilization studies are indicated before a tape can be recommended for clinical use. The

perfection of this tape should prove a simple effective method for the treatment of many surgical conditions and war wounds

8 A second article, on further experimental studies, is in preparation

Many Army medical officers and enlisted men assisted in carrying on these experiments during the past eighteen months, under varied and difficult conditions

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GUNSHOT WOUND OF THE THORACIC ESOPHAGUS

Report of a Case

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RECOVERY following an injury to the thoracic esophagus by an extrinsic foreign body is believed to be exceedingly uncommon. This impression is further borne out by a quotation from a Hunterian Lecture delivered by Gordon-Taylor at the Royal College of Surgeons of England in May 1944, and subsequently published in the *British Journal of Surgery* "The story of wounds of the œsophagus is not unnaturally dispiriting [in the] National War Collection. I am informed, however, that Lt-Colonel A. L. d'Abreu has actually saved a man wounded in the thoracic œsophagus which must rank as one of the most splendid triumphs of surgical prowess." In view of the infrequency with which recovery is known to occur following such injuries, it seems of interest to report the following case.

REPORT OF CASE

A 20 year old soldier, while participating on May 17, 1944 in a field problem in which live ammunition was being used, was hit in the back by a spent bullet. His condition on arrival at the hospital was good in spite of a difficult litter evacuation from a wild and heavily wooded jungle training area. Prior to his arrival he had received 1 unit of plasma.

He appeared extremely anxious and apprehensive on admission and volunteered the information that swallowing saliva caused increased pain in his chest. He was in mild respiratory distress, although cyanosis was not noted. There was a small round wound of entrance about $\frac{1}{4}$ inch (0.6 cm) in diameter between the inner edge of the scapula and the spine on the left side at the level of the third rib. The wound was not sucking air. The blood pressure was 110 systolic and 80 diastolic, the pulse rate 110 and the respiration rate 40 per minute. The heart sounds were of good quality, and the heart did not appear to be displaced. There was increased dullness to percussion over the left lung, and auscultation showed decreased breath sounds and coarse rales. The breath sounds over the right lung were essentially normal. The remainder of the physical examination revealed nothing abnormal.

The patient was immediately grouped for transfusion and administration of plasma was started. Roentgenograms were taken, and stereoscopic views showed a 30 caliber bullet lying in the posterior mediastinum, somewhat anterior to the body of the third dorsal vertebra (fig 1).

The course of the missile, the location of the bullet as seen on stereoscopic examination and the complaint of pain by the patient on swallowing indicated clearly that serious injury had been sustained by the esophagus.

The patient was prepared for operation, and the anesthesia started fifty-five minutes after his arrival at the hospital. This was approximately three hours following his injury.

Pentothal sodium supplemented by nitrous oxide, oxygen and ether under varying increases of atmospheric pressure were used to produce anesthesia. Fluids, plasma and whole blood were given intravenously throughout the operation.

A posterior mediastinotomy was done in the manner described by Lilienthal for access to the upper posterior part of the mediastinum. A vertical incision was made between the inner border of the left scapula and the spine. The sixth rib was resected for about 2 inches (5 cm.) lateral to the articulation with the vertebra. The fourth and fifth ribs were then transected, and the third rib, which had been



Fig 1—Roentgenogram showing the 30 caliber bullet lying in the posterior mediastinum.

badly splintered by the bullet, was partially resected. A portion of the fourth rib was also removed later to facilitate exposure.

The posteromedial pleura was reflected and the lung displaced forward and laterally. It was now seen that the bullet had traversed the inner margin of the left lung. The left pleural cavity began filling with air through two closely located entrance and exit wounds in the pleura. Positive pressure anesthesia was instituted. Damage to the lung and hemorrhage were minimal, and the lung parenchyma required no special attention. The aorta and esophagus were then brought into view. The left posterolateral wall of the esophagus was seen to have a $\frac{1}{4}$ inch round hole where it had been pierced by the missile. Palpation

revealed the bullet lying anterior to the esophagus against the trachea at a point near the bifurcation. The esophagus was mobilized and the loose areolar blood-infiltrated tissues separated, bringing the bullet into view. After removal of the bullet a second hole was found in the anterior wall of the esophagus. The exit wound was a tear about $\frac{3}{8}$ inch (1 cm) in length. The trachea escaped undamaged. Both holes in the esophagus were sutured with an atraumatic no 0 chromic surgical gut. The periesophageal mediastinum was given free drainage by means of four large Penrose tube drains. The two holes in the pleura were then sutured with a continuous atraumatic no 0 chromic surgical gut stitch. The pneumothorax was then aspirated from the left pleural cavity and 15,000 units of penicillin in isotonic solution of sodium chloride was introduced. The mediastinum was likewise irrigated with penicillin solution 250 units per cubic centimeter. The thoracic wall was then repaired by approximating the intercostal muscle bridges and partially closing the deepest layer of spinal muscles. Six grams of sulfanilamide powder was dusted into the mediastinum and the wound of entrance. The more superficial layers of the wound were packed open with petrolatum gauze and primary and secondary sutures placed for tying at a later date.

The condition of the patient remained good throughout the operation. The blood pressure at the start of the procedure was 118 systolic and 80 diastolic and the pulse rate 116. The lowest blood pressure recorded was 110 systolic and 80 diastolic and the highest pulse rate was 128. The blood pressure at the close of the operation was 138 systolic and 100 diastolic, and the pulse rate was 118.

The patient was immediately placed in an oxygen tent on return to the ward. He was given 20,000 units of penicillin intramuscularly every two hours.

Several major postoperative problems were encountered in the management of this case which centered around two most serious complications. The first of these had to do with a rapidly increasing sensitivity of high degree to opium derivatives. This rare condition, developing on top of a cardiorespiratory mechanism already embarrassed by a contused left lung, mild hemopneumothorax, tenacious bronchial secretion and beginning atelectasis in the contralateral lung was not fully appreciated until the precipitation of an acute cardiorespiratory crisis following the intramuscular injection of $\frac{3}{8}$ grain (0.008 Gm) of pantopon on the third postoperative day. Prolonged artificial respiration was necessary. An emergency tracheotomy was done and proved worth while in that oxygen exchange was improved and the aspiration of tenacious bronchial secretions facilitated. From this point on the patient was never given any opiate. Restlessness and pain were controlled by the rectal administration of large doses of paraldehyde.

The second complication, which followed closely on the first, was mediastinitis. On the evening of the second postoperative day the patient appeared extremely toxic and the temperature rose to 105 F rectally. The hemothorax had never been more than moderate and was easily controlled by occasional thoracentesis. After each aspiration 20,000 units of penicillin in isotonic solution of sodium chloride was instilled into the pleural cavity. The dosage of penicillin was maintained at 240,000 units daily by intramuscular injection. Five grams of sodium sulfadiazine was also given intravenously each day. Blood sulfadiazine levels were reported at this time between 57 mg and 11 mg per hundred cubic centimeters. Cultures taken from around the mediastinal drains showed a heavy growth of gram-negative bacillus of the colon group.

On the fourth postoperative day the patient was much less toxic and was generally improved. The temperature dropped to 100.8 F, and despite a secondary rise of temperature on the sixth postoperative day to 104.5 F, it appeared that he would recover from the mediastinitis. Subsequent cultures taken from around

the mediastinal drains showed a light growth of alpha hemolytic streptococci and a heavy growth of hemolytic *Staphylococcus aureus*

His improvement was sufficiently rapid from this point on that it was decided not to do a gastrostomy. In addition to the intravenous administration of dextrose, he received four blood transfusions, as well as 2 to 3 units of plasma (500 to 750 cc) daily. Thiamine hydrochloride and ascorbic acid were also given intramuscularly.

On the ninth postoperative day the patient was allowed $\frac{1}{2}$ ounce (15 cc) of water hourly by mouth. There was no indication of any leakage or ill effect. The administration of sulfadiazine was discontinued at this time, owing to a falling white blood cell count. By the eleventh postoperative day the patient was able to remain out of the oxygen tent without any respiratory embarrassment or discomfort.

The tracheotomy tube was removed on the thirteenth postoperative day. At this time the dosage of penicillin was reduced to 120,000 units daily. Minor

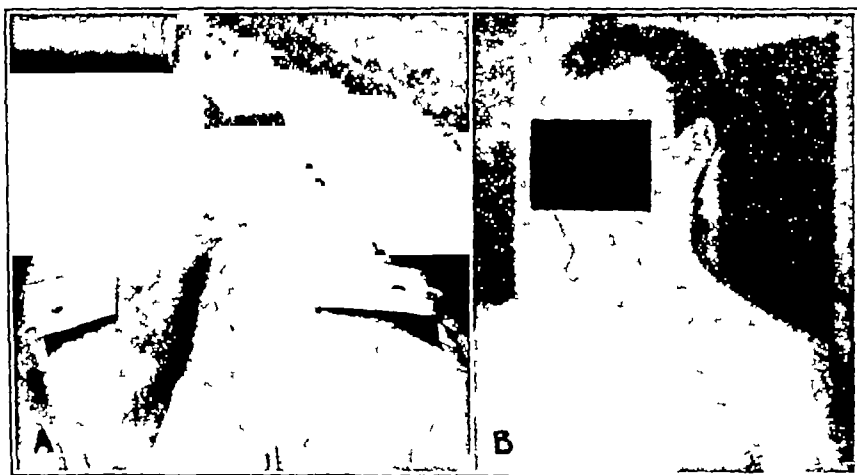


Fig 2—*A*, three months following injury, showing healed wound of entrance and thoracotomy incision, *B*, general appearance three months following injury. Note the tracheotomy wound.

difficulties arose in the management of the wound because of its nature and depth. The penicillin was reduced to 90,000 units daily on the fifteenth postoperative day and discontinued entirely on the thirty-second postoperative day. He had received a total of 4,720,000 units at the time the drug was discontinued.

He has made a completely satisfactory recovery. Four months after injury deglutition was normal and fluoroscopic examination of the esophagus with barium sulfate revealed no evidence of stricture (fig 2).

COMMENT

The failure to culture organisms from the left pleural cavity is worthy of note when one considers the complex mediastinal infection. In view of the nature of the latter the combined use of sulfonamide compounds and penicillin from the start appears to have been justified. It is impos-

sible to allocate a percentage effectiveness to either chemotherapeutic agent. One or the other, or both in combination, unquestionably contributed to the successful outcome in this case.

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TOXEMIA SYNDROME AFTER BURNS

BIOCHEMICAL AND PATHOLOGIC OBSERVATIONS AND STUDIES

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PHILADELPHIA

Following an extensive thermal burn, a complex derangement of normal physiologic processes develops, which can be separated into at least two components, shock and toxemia. Most of the recent developments in the systemic treatment of burns have been directed toward lessening the severity of shock, and as the treatment of shock has improved one has seen more patients survive the period of shock only to succumb to toxemia.

For many years shock and toxemia were regarded as one process. Observers debated whether the whole picture was due to toxins produced in the area of the burn and distributed throughout the body by the circulation or whether the local loss of plasma in the burned area, with the resultant disturbance of circulation dynamics, was the primary cause of systemic damage.

In 1923 the toxin theory, supported by the work of Boyd and Robertson,¹ was in the ascendency, but during the next decade the work of Underhill and co-workers² and that of Shock³ advanced the second, or physical, theory of shock. There was a tendency to claim the changes in the parenchymatous organs as entirely secondary to the poor circulation occurring during the period of shock.

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The work described in this paper was done under contract, recommended by the Committee on Medical Research between the Office of Scientific Research and Development and the Pennsylvania Hospital.

Boyd G L, and Robertson, B. Toxemia of severe Superficial Burns in Children, *Am J Dis Child* **25** 163 (Feb) 1923

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Wilson, Macgregor and Stewart⁴ in 1938 distinguished the two pathologic processes and noted that while they might overlap at the end of the first twenty-four hours after the burn the two were usually distinguishable. The shock phase is marked by hemoconcentration, fall in blood pressure, rapid pulse and cold extremities. The patient usually recovers from shock within twenty-four hours unless death has supervened. The phase of toxemia, on the other hand, produces headache, vomiting, drowsiness, fever and oliguria and usually makes its appearance on the second day, lasting three or four days. Patients dying in the phase of toxemia show changes in the parenchymatous viscera, liver, kidneys and adrenal glands and also in the intestine and the central nervous system that are not seen in patients dying of shock within the first day or so. The changes observed in patients dying during toxemia are not, however, considered pathognomonic, since somewhat similar changes have been produced in experimental animals by prolonged low blood pressure and by hyperthermia.

The paper of Wilson, Macgregor and Stewart⁴ and early reports from the Pennsylvania Hospital⁵ were written during the period when local treatment usually consisted in tanning the burned surface and when changes in hepatic function were the most pronounced characteristic of toxemia. After Wells, Humphrey and Coll⁶ demonstrated the hepatotoxic properties of tannic acid and Hartman and Romence⁷ showed the same disturbance following the use of silver nitrate, it was thought by some investigators that burn toxemia might prove to be an artefact. However, this has not proved to be the case. While the clinical symptoms and

⁴ Wilson, W C, Macgregor A R, and Stewart C P. *Brit J Surg* **25** 826, 1938

⁵ Wolff, W A, Elkinton J R and Rhoads J E. *Ann Surg* **112** 158 1940

⁶ Wells D B, Humphrey, H D., and Coll J J. *New England J Med* **226** 629 1942

⁷ Hartman F W and Romence, H L. *Ann Surg* **118** 402 1943

the laboratory findings in burn toxemia were notably affected after the use of tannic acid and to a less extent after the use of other tanning agents, our studies indicate that the process is widespread and not limited primarily to damage of the liver

With this in mind, we have reviewed the data on burn toxemia obtained at the Pennsylvania Hospital during the past five years during which studies have been made on 213 burned patients

The original studies were made on patients admitted to the service of Dr W E Lee at the Pennsylvania Hospital and the Graduate Hospital of the University of Pennsylvania prior to 1941. During 1941 and 1942 staff members of seven Philadelphia hospitals made cases available for study under a contract between the Pennsylvania Hospital and the Office of Scientific Research and Development, and during 1943 and 1944 staff members of a much larger group of hospitals in the Philadelphia area aided the study by making cases of severe burns available for study

In 1940 a series of tests of hepatic function was carried out on 3 burned patients treated at the Pennsylvania Hospital. These patients were given plasma promptly after injury, and it is believed that at no time were they in shock but, nevertheless they showed definite impairment of hepatic function

Some test of hepatic function was carried out on 154 patients, with a rather extensive series of tests of hepatic function in 51 of these patients. In the 154 cases local treatment varied. In 14 cases tannic acid was used, and in 53 cases other tanning agents were used. In the remaining cases the local treatment was with petrolatum gauze and pressure dressings. In a considerable group Eschatin (an adrenal cortex extract) was used for at least forty-eight hours. Desoxycorticosterone acetate was given intramuscularly to a small number of patients. Nearly all the patients were given large quantities of plasma when there was hemoconcentration. Twelve patients received 3 to 5 liters of sixth-molar sodium lactate solution orally each day during the first six to ten days after the burn in addition to the parenteral administration of plasma.

In addition to the studies of hepatic function,⁸ a careful study of renal function was carried out on 28 patients in 1943-1944, including fractionation of nonprotein nitrogen in blood and urine.⁹

During 1943-1944, 26 patients died, and 23 of the cases came to autopsy. The data to be presented are based on the observation and study of these cases and represent the combined efforts of a considerable group of workers

TESTS OF HEPATIC FUNCTION

For purposes of comparing the effect of different methods of local treatment on hepatic function, we have depended on the van den Bergh reaction for two reasons: first, because it was found to reflect the general change in hepatic function and second, because it had been carried out on most of the patients studied during the time when tanning agents were in general use as well as on the patients in more recent cases. A level of less than 0.5 mg of bilirubin per hundred cubic centimeters of serum was regarded as normal. Only 7 per cent of the patients treated with tannic acid showed a serum bilirubin level within this limit, as compared with 47 per cent of the patients treated with petrolatum and pressure dressings. Elevation of the serum bilirubin above 2 mg per hundred cubic centimeters of serum was considered to be an indication of severe impairment of hepatic function, and this was corroborated by other tests of hepatic function. This degree of elevation occurred in 29 per cent of the group treated with tannic acid, in 18 per cent of the group treated with other tanning agents and in only 7 per cent of the group treated with petrolatum and pressure dressings. Furthermore, the three highest levels of serum bilirubin observed in this series occurred in the small group treated with tannic acid (11 mg, 13 mg and 16 mg per hundred cubic centimeters of serum).

It seems fair to conclude from these data that treatment with tannic acid resulted in more damage to the liver than when petrolatum gauze was used but that some impairment of hepatic function occurred as a result of the burn itself and was presumably inherent in the pathologic process resulting from the burn. The data also indicate that the other tanning agents, silver nitrate, gentian violet medicinal and triple dye were not free of noxious influence on hepatic function. The results in the latter group stand midway between the results for patients treated with tannic acid and those for patients treated with petrolatum gauze.

Corroboration of the degree of damage to the liver indicated by the van den Bergh reaction was obtained from the determinations of retention of sulfobromophthalein sodium, conjugation of benzoic acid and flocculation of cephalin-cholesterol emulsion. In addition, certain spe-

⁸ Saltonstall H, Walker, J, Rhoads, J E, and Lee W E. To be published.

⁹ Walker J Jr. To be published.

cial studies of hepatic function were carried out. Among these were the bilirubin clearance test and the determinations of plasma alpha amino nitrogen and of the albumin-globulin ratio. None of these seemed more sensitive than the standard procedures mentioned. Of the three, the bilirubin clearance was the most valuable but was extremely susceptible to alteration by factors not related to the pathologic changes in the burned area. The alpha amino nitrogen remained remarkably constant. The albumin-globulin ratio showed striking changes, but these generally occurred late in the clinical course and could not be correlated with the results of other tests of hepatic function. Repeated determination of the albumin-globulin ratio showed that it tended to become reversed ten to fifteen days after the burn and that this reversal persisted in the patients with extensive third degree burns until the granulating areas had been covered with new skin. In view of the recent investigations of Hirshfeld and his associates¹⁰ on the protein loss from burned surfaces, it would seem that the reversal of the albumin-globulin ratio was an index of the state of the protein nutrition rather than of the hepatic function of the patient.

RENAL FUNCTION

It has long been recognized that renal function is impaired in a severely burned patient. Albumin, casts, hemoglobin and red blood cells frequently appear in the urine and it was formerly thought that the loss of albumin in the urine might be an important factor in the development of hypoproteinemia. The volume of urine excreted is usually considerably decreased from the second to the fourth or fifth day after the burn and in some cases may be drastically decreased. In 2 of our cases the urine output dropped to 30 cc a day for a short time. In the group of cases in which fluid was forced in the form of sixth-molar sodium lactate solution it was possible to increase the urine output decidedly.

The level of plasma nonprotein nitrogen tends to be noticeably raised in burn toxemia. In 10 patients it rose over 100 mg per hundred cubic centimeters of plasma and 9 of these patients died during the toxic phase. The tenth patient survived for two months to die of a pulmonary embolus. Of the 13 patients who died with lower nonprotein nitrogen levels, 3 had received electrical burns and it was thought that

the electric current had injured deeper tissues, 3 others appeared to die as the result of pre-existing disease and the remaining patients had nonprotein nitrogen levels of over 80 mg per hundred cubic centimeters of plasma.

It is also striking to note how closely the extent of the area burned and the survival may be correlated.

Investigation of the plasma nonprotein nitrogen elevation was carried out by Walker⁹ in an attempt to find out which fraction was chiefly responsible for the rise. In normal blood the distribution of these fractions is reasonably constant. Urea nitrogen, uric acid nitrogen, creatinine nitrogen and alpha amino nitrogen were determined. The residue of nonprotein nitrogen left unaccounted for was called the "undetermined" nitrogen. In the patient with burn toxemia it was found that 50 to 80 per cent of the rise was due to an increase in the undetermined fraction.

At present we know of no evidence regarding the behavior of the undetermined nitrogen fraction in other forms of toxemia, so that it is not known whether or not this is specific for burns. The inference is that it probably is not specific. The idea, of course, suggests itself that this undetermined nitrogen fraction may represent degenerative products which are of themselves toxic, but this remains to be proved. The rise in the undetermined nitrogen level seems definitely of prognostic significance, whether it is specific for burn toxemia or not.

PATHOLOGY

Seventeen of the patients in the 1943-1944 series died and autopsy was performed. Five of the patients died between two and six days after the burn in what was clinically evident as toxemia. In addition 1 patient died fifteen minutes after a 95 per cent burn, apparently of shock and asphyxia. Sections from the organs of this patient were used as controls. Two patients who showed pronounced evidences of toxemia during the first week survived this period and died later, one on the nineteenth day, of purulent meningoencephalitis and the other on the sixty-second day, of pulmonary embolism.

Photomicrographs of the livers of these patients dying in the toxemia phase show fatty infiltration but no actual necrosis (fig 1).

The kidneys showed rather pronounced toxic nephrosis in all cases. Grossly the organs were swollen and dark and orange-yellow. A typical section of the capsule showed a pale reddish-pink cortex. Microscopically there was pronounced

10. Hirshfeld, I. W., William, H. H., Apple, W. J., Heller, C. G. and Pillner, M. A. *Surgery* 15: 70, 1944.

degeneration of entire tubules, while the glomeruli were intact (fig 2)

The adrenal glands did not show gross hemorrhage in any of the cases studied, but in all there were edema and degeneration of the inner zone of the cortex (fig 3)

Sections of kidney and adrenal tissue from a patient dying within fifteen minutes after sustaining a 95 per cent burn are included as controls for comparison with tissues from patients dying of burn toxemia (figs 4 and 5)

No cases of Curling's ulcer were seen, but sections of the duodenum from the 5 patients

medulla oblongata Microscopically, there is general toxic degeneration of ganglion cells, which is most evident in the cortex and the hypothalamus

All the organs of these patients were peculiarly flabby, and all the tissues were edematous The edema seemed unrelated to the amount of fluid the patient received in the course of therapy The edema of the lungs and other organs did not seem perceptibly greater in patients who received 3 to 5 liters of sixth-molar sodium lactate solution daily in addition to plasma than

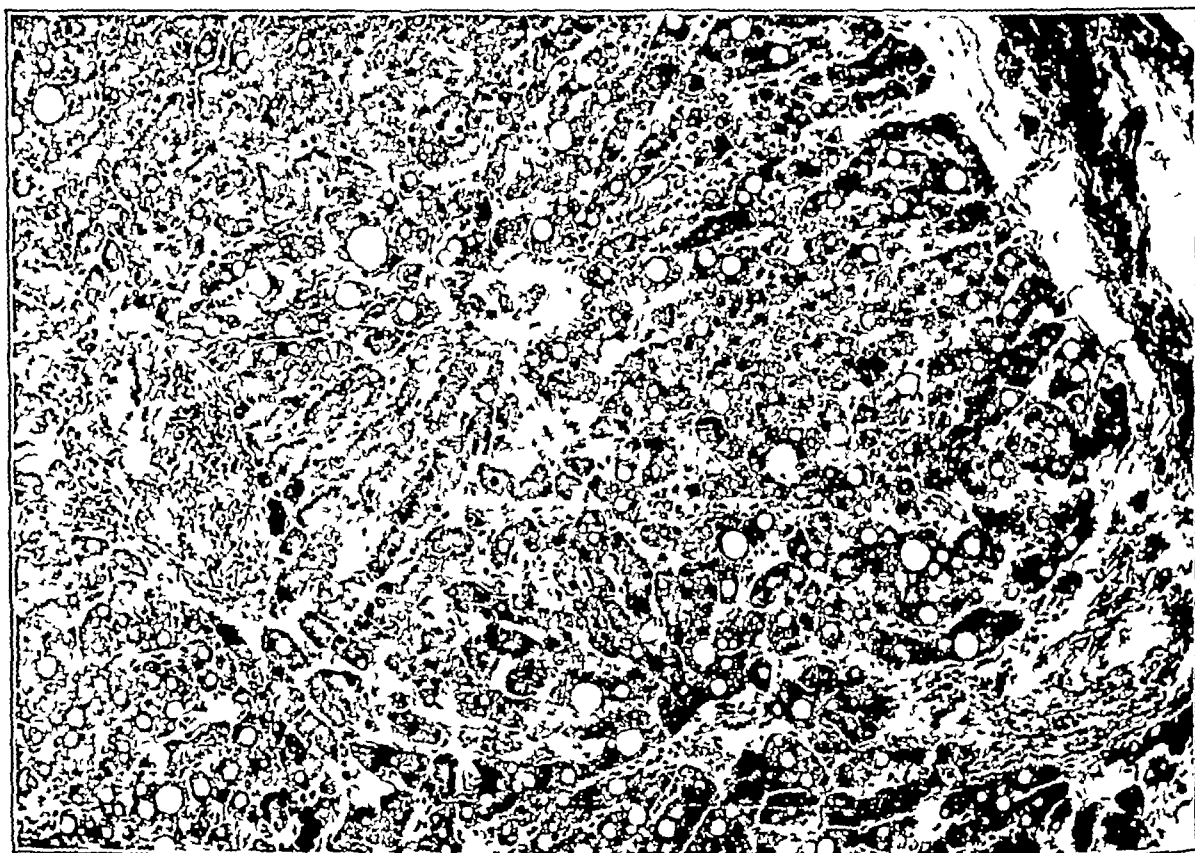


Fig 1—Moderately advanced fatty degeneration of the liver, more pronounced centrally ($\times 153$)

dying in toxemia showed pinpoint multiple ulcerations with focal collections of leukocytes

The changes in the brain have been studied comparatively little in the past, but they are striking and probably of much greater importance than has been generally suspected We have reported these findings in detail¹³ Gross examination of the brains of 6 patients dying of toxemia showed edema in every case and evidence of herniation of the cerebellar tonsils into the foramen magnum, with compression of the

in those who received plasma and smaller amounts of dextrose and water

COMMENT

In using the term "toxemia," we do not wish to indicate that there is necessarily a circulating toxin produced by the burn This has not yet been demonstrated in man, although Netzký¹⁴ recovered a hemolysin from the lymph in burned dogs and Netzký and Leiter¹⁵ provided a convincing demonstration of a generalized increase

¹¹ and ¹² Deleted by author

¹³ Walker, J, Jr, and Shenkin, H Studies on Toxemia Syndrome after Burns Central Nervous System Changes as Cause of Death, *Ann Surg* **121** 301-303 (March) 1945

¹⁴ Netzký, M Personal communication to the authors

¹⁵ Netzký, M G, and Leiter, S S *Am. J. Physiol* **140** 1, 1943



Fig 2—4, tubular degeneration of the kidney with sloughing of lining cells ($\times 153$) B, pronounced tubular degeneration of kidney. The epithelial cells are vacuolated. The glomerulus is intact ($\times 594$)

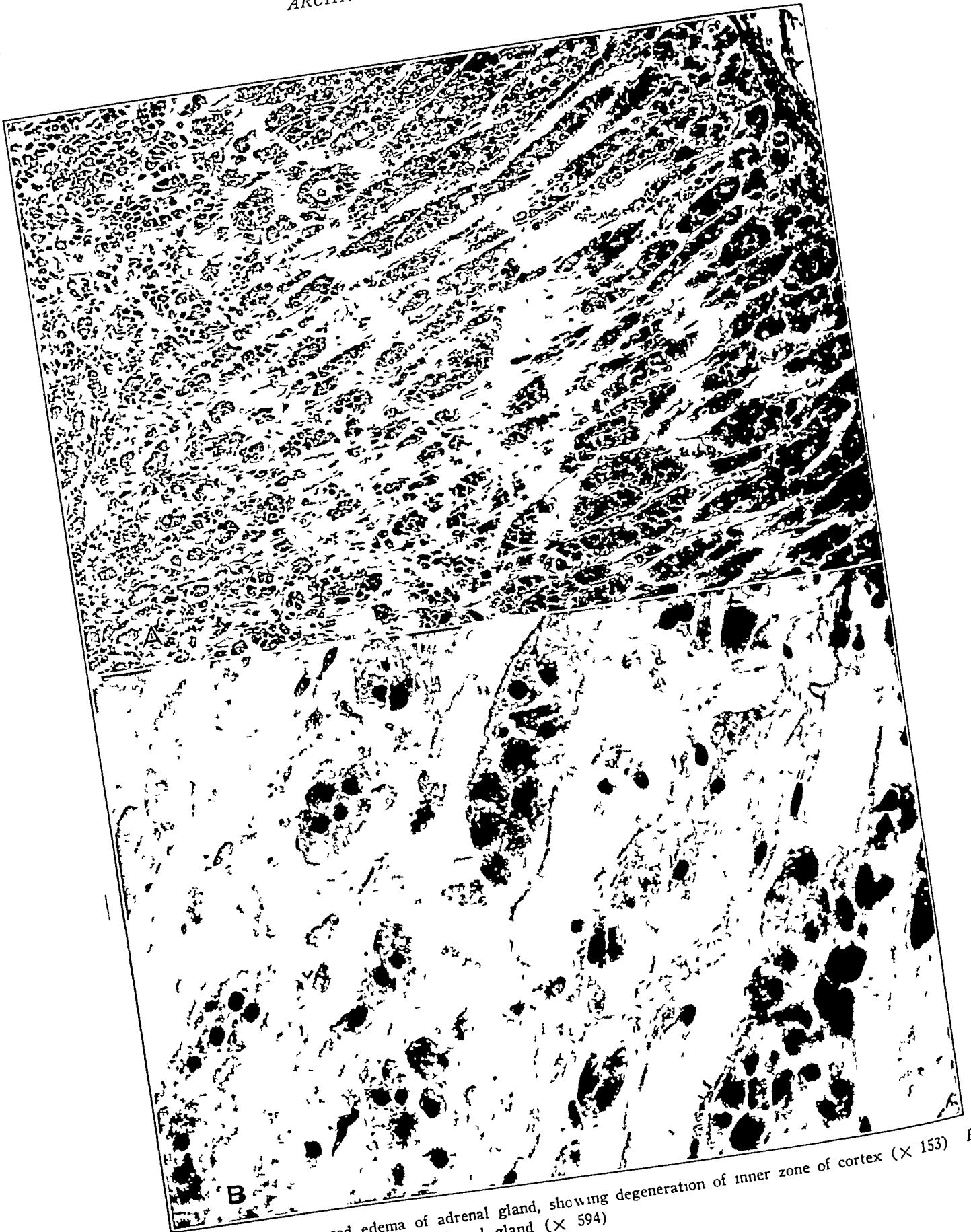


Fig 3—A, pronounced edema of adrenal gland, showing degeneration of inner zone of cortex ($\times 153$) B, pronounced edema and autolysis of adrenal gland ($\times 594$)

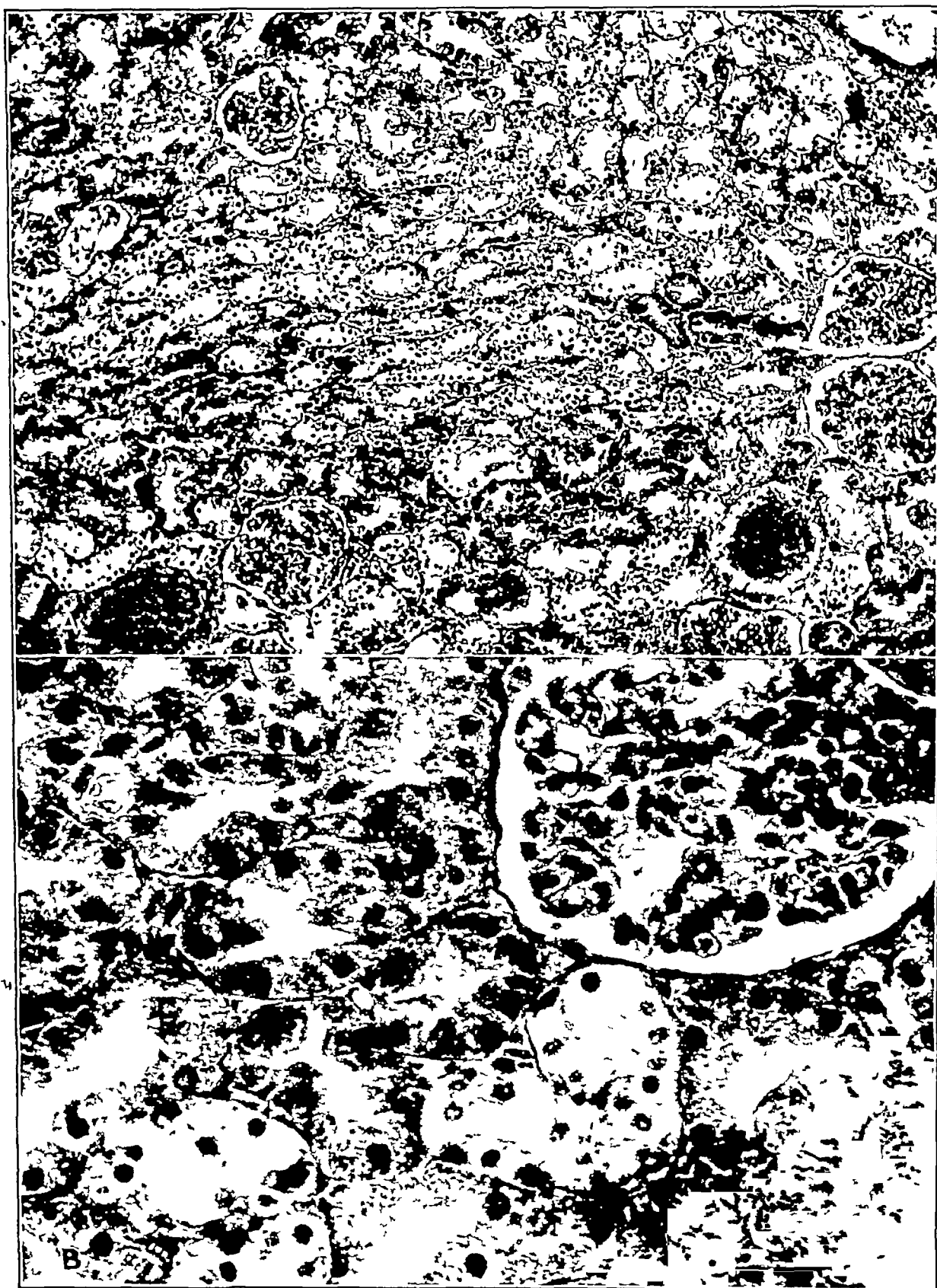


Fig 4—A, an essentially normal kidney ($\times 153$) B, an essentially normal kidney ($\times 594$)

in the permeability of the dog's vascular tree for heterologous serum protein following a burn. This increase occurred not only in the region of the burn but in distant areas as well. The term "toxemia" is merely a convenient one for describing the symptom complex that occurs.

The patients with a diagnosis of toxemia were mentally normal for a few hours after the burn but thereafter definite aberration soon developed. This usually took the form of a stupor that sometimes passed into coma. There was always disorientation in severely burned patients and occasionally mania. Muscular twitchings were often observed. The patients frequently com-

the pulse rate were usually somewhat elevated before this occurred but not any more strikingly than in those cases which did not terminate fatally.

The controversy between those investigators who have postulated a circulating burn toxin and those who have upheld the view that lesions in distant organs result from circulatory changes induced by a fluid shift in the locality of the burn need not be prolonged here. It is important, however, to recognize that changes in distant organs do occur after practically all severe burns. The damage can often be measured by tests of function during life and is usually evident

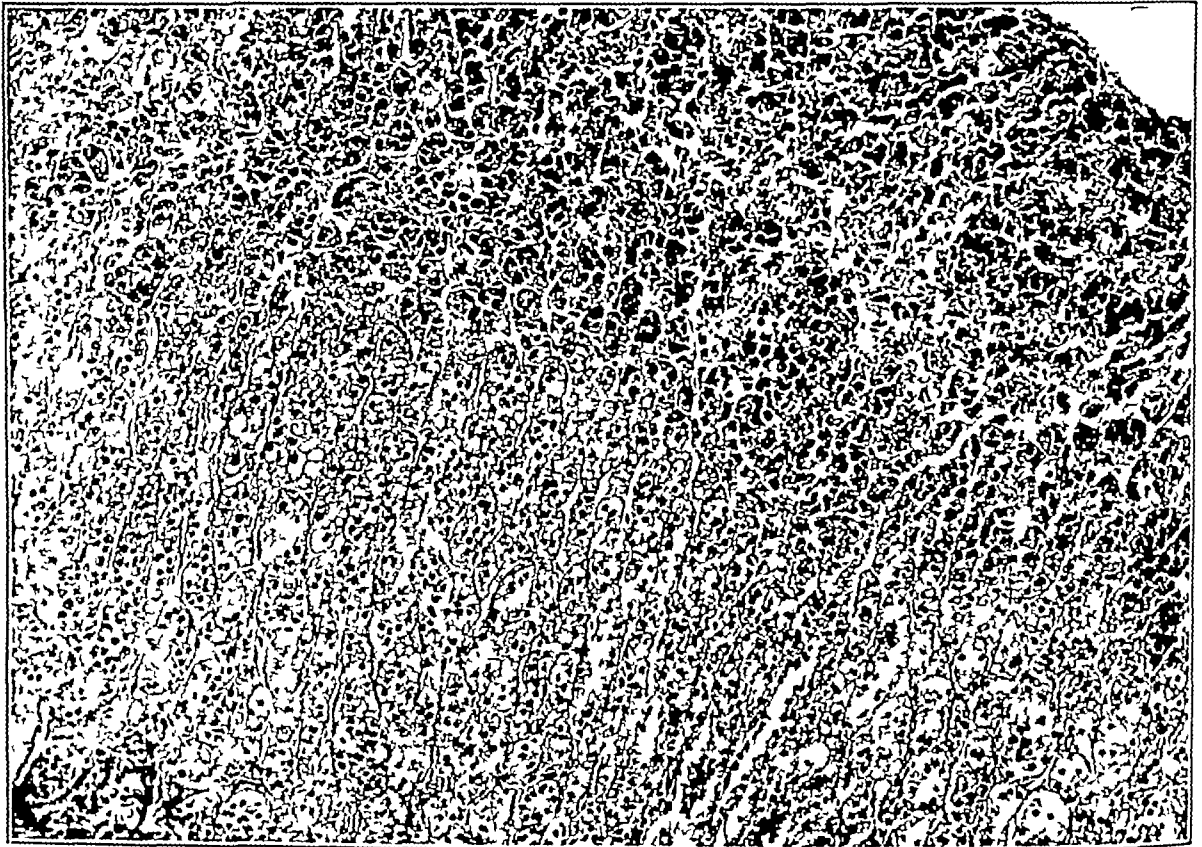


Fig 5—The adrenal glands, with slight beginning edema in inner zone of cortex. It is otherwise normal ($\times 153$)

plained of headache and nausea and vomiting usually occurred. Oliguria frequently developed within the first twenty-four hours, and sometimes became extreme.

Cheyne-Stokes respirations were noted in the severely burned patients, and in 1 patient respirations ceased on two occasions and had to be carried on artificially for periods of ten minutes the first time and three minutes the second. In fatal cases death frequently occurred with abrupt respiratory failure, usually on the fourth or fifth day and often when urinary output was increasing and the general condition of the patient seemed much improved. The temperature and

histologically in patients dying of burns in two to seven days. These changes affect particularly tissues with high oxygen consumption, such as kidneys, adrenal glands, brain and liver. Furthermore, there is evidence at autopsy of widespread edema of the tissues.

The discovery of the hepatotoxic qualities of tannic acid is an important advance, and the abandonment of this agent and of other tanning agents has altered the picture of toxemia. Whereas in 1940 the changes in hepatic function dominated the picture of toxemia and pronounced necrosis of the liver was frequently found at

autopsy,¹⁶ since the abandonment of the tanning agents the changes in the liver generally have been mild. In our experience, however, the patient with third degree burn of about a third of the body surface was still in grave danger of dying, and death occurred in about the same percentage of patients whether tanning agents were used or not. This implies that the hepatic damage following tanning seldom caused death and explains the fact that tannic acid was almost universally used without attracting attention to its toxic properties.

After the use of the tanning agents was given up and there was less evidence of hepatic impairment, the evidence of renal injury became more evident. The rise in nonprotein nitrogen was found to be strikingly related to prognosis. The urinary output was at times extremely low. By increasing the fluid intake, it was possible in most cases to maintain a good urinary output, but the rise in the nonprotein nitrogen took place nevertheless.

The breakdown of the nonprotein nitrogen fraction of the plasma yielded the interesting information that in most cases the rise occurred mainly in the undetermined fraction and not proportionately in all the fractions, as one might expect in renal insufficiency. It appears, therefore, that the renal injury, although severe histologically, was perhaps not critical functionally and that the patients did not die of uremia. One might postulate that there was a selective decrease in the ability of the kidney to excrete this undetermined portion of the nonprotein nitrogen, but analysis of the urine showed that excretion of this fraction was usually increased in all cases at some time in the toxic period. Therefore, unless one postulates a difference between the undetermined fraction in the urine and that in the plasma, one cannot regard the increase in the blood as due to renal insufficiency. It seems fairly certain that the rise is due to a great increase in the production of this material following a burn, and it is hard to escape the conclusion that it represents breakdown products of tissue protein and perhaps of blood.

Underhill² argued against the theory of absorption of a local toxin, since he found a diminished rate of absorption of phenolsulfonphthalein and strychnine from the burned areas. However, Wolff, Elkinton and Rhoads⁵ observed that toxemia was usually most severe about the fourth day after injury and that at this time the local edema at the site of the burn began to disappear visibly.

Since the burn "toxin" has been so elusive, it is natural to believe that it is a substance of comparatively low toxicity, of which a considerable amount must accumulate to cause death. One obvious place to look for it is in the undetermined fraction of the plasma nonprotein nitrogen, and it is interesting that such sharp correlation was found between the concentration of this fraction and the occurrence of death.

If death in burn toxemia does not occur from hepatic damage or from renal damage, what is its mechanism? The mental stupor, the myoclonus, the sudden respiratory arrest and the post-mortem changes in the brain all point to the possibility that death may be of central nervous origin, and we believe that certain of the deaths are brought about in this way. Whether edema and medullary compression, on the one hand, or degenerative changes in the ganglion cells, on the other hand, are of primary importance is impossible to say. If the edema is the decisive factor, tapping the ventricles might be of value. This method has not yet had a trial so far as we know.

Forcing of fluids, such as isotonic sodium lactate and sodium chloride solutions, after a burn should tend to increase renal function and perhaps hasten the excretion of plasma nonprotein nitrogen. This may be advantageous, but it has not been adequately proved to be so. On the other hand, such administration of fluids would be likely to increase the occurrence of edema of the brain, according to the studies of Weed and McKibben.¹⁷ Administration of fluids in the cases observed by us apparently did not precipitate the respiratory arrest, and this phase of the subject requires further study.

In all the patients in whom we observed fatal burn toxemia there was extensive third degree involvement. All the burns were due to flame. It is our impression that the changes following first and second degree burns may be somewhat different. Certainly these mild burns deserve separate consideration until there is proof that the changes produced are of the same nature as those produced by third degree burns.

CONCLUSIONS

Burn toxemia is to be distinguished from burn shock, as pointed out by Wilson, Macgregor and Stewart.⁴

Damage to the liver, both functionally and histologically, is usually mild if tanning agents are not used in the local treatment of the burned surface.

16 Erb, I. H., Morgan, E. M., and Farmer, A. W. *Ann Surg* 117: 234, 1943.

17 Weed, L. H., and McKibben, P. S. *Am J Physiol* 48: 531, 1919.

The reduction in hepatic damage achieved by avoiding tanning agents has not yet resulted in any pronounced reduction in mortality

Renal damage, consisting in a toxic nephrosis, was a constant part of the picture of toxemia in fatal cases

Urea clearance frequently falls below 10 per cent of average normal function

There is a pronounced rise in the plasma non-protein nitrogen, which is of considerable prognostic significance. Elevations of plasma non-protein nitrogen above 100 mg per hundred cubic centimeters were seen only in fatal cases

The elevation of plasma nonprotein nitrogen is not readily explained on the basis of renal damage alone. Sixty to 80 per cent of the rise in nonprotein nitrogen was due to an increase in the undetermined fraction

The rise in this undetermined fraction is sufficiently well correlated with the clinical picture of toxemia that it serves as a useful criterion of the presence and severity of toxemia after a burn during the first week

Certain deaths from burns seem best explained on the basis of damage to the central nervous system. Pronounced changes, consisting in degeneration ganglion cells and edema, occurred and were most pronounced in the hypothalamus and cortex

Burn toxemia is a widespread process involving many if not all of the organs and tissues, and no specific treatment is as yet known

The coroner's office of the city of Philadelphia and Dr Benjamin A Guley gave valuable cooperation

PROGRESS IN ORTHOPEDIC SURGERY FOR 1944

A Review Prepared by an Editorial Board of the American Academy of
Orthopaedic Surgeons

XV The Knee Joint

PREPARED BY R K GHORMLEY, M D ROCHESTER MINN

Embryology —Haxton ⁴⁷³ investigated the relative patellar breadth in two hundred and thirty-four mammalian limbs, including specimens from representatives of the principal orders, and reached the following conclusions 1 The "patellar index" is not related to the size or the speed of movement of an animal 2 There is no evidence that the patella is undergoing phylogenetic retrogression 3 There is evidence that it has a functional value in extending the knee joint

Schifino and Griffo ⁴⁷⁴ reported a case of trauma of the knee in which there was a separate fragment at the superior and lateral border of the patella Roentgenographic examination of the opposite knee disclosed the same change They note that Thurston Holland regarded this as an abnormality due to rickets and that Mouchet and Fornier thought that it was an apophysitis like that which occurs in osteochondrosis of tuberosity of the tibia (Osgood-Schlatter's disease)

Wounds and Injuries —Buxton,⁴⁷⁵ in a Hunterian lecture reviews gunshot wounds of the knee joint which occurred before World War I in World War I, in the postwar period and in World War II (in France and the Middle East) In brief, the treatment included immobilization (not skeletal traction), chemotherapy, aspiration for distention and removal of metallic fragments in the joint or the articular cartilage Motion was instituted as soon as possible In cases in which the patients are not observed soon after the injury and in cases in which infection appears likely to occur, the synovial membrane is not closed If the joint is infected and repeated aspiration fails to produce relief the joint is opened on each side and irrigated, it rarely is closed but usually is left open and immobilized The author reviews 255 cases of

473 Haxton, H The Patellar Index in Mammals, *J Anat* **78** 106-107 (April) 1944

474 Schifino, F J, and Griffo, A E Patella partita bilateral, *Semana med.* **1** 441-442 (March 2) 1944

475 Buxton, St J D Gunshot Wounds of the Knee-Joint, *Lancet* **1** 681-684 (May 27) 1944

gunshot wounds of the knee joint that were observed in base hospitals during the second and third battle in Libya. In 18 of the 255 cases, there were gunshot wounds of both knee joints. Suppurative arthritis occurred in ninety-five (34.8 per cent) of the two hundred and seventy-three wounded knees. Amputation was performed in 12 cases, and 3 of the patients died.

Seley⁴⁷⁶ reports a case in which a popliteal aneurysm resulted from a gunshot wound of the knee joint. The usual conditions were noted, and relief was obtained by endoaneurysmorrhaphy.

[ED NOTE—The experience of surgeons caring for traumatic aneurysms and arteriovenous fistulas in the service hospitals will bring this type of surgical procedure to its highest state of perfection. They are doing an excellent job.]

Allan and Nicholson⁴⁷⁷ report 153 cases of injury of the knee joint. In 98 of the cases the patients were hospitalized, and arthrotomy was performed in 44 cases. In 32 of the 44 cases in which arthrotomy was performed, there was an injury of a cartilage. The most frequently encountered lesion was a bucket handle tear. Loose bodies were encountered in 10 cases. Diagnosis of meniscus injury was made on the basis of the following observations: (1) incomplete extension, (2) painful cartilage area with extension, (3) localized tenderness, (4) discomfort on rocking the tibia and (5) localized pain elicited by sharp tibial rotation with the knee flexed. The nonoperative treatment of any injury was aspiration, immobilization (six weeks), injection of procaine hydrochloride for tendon sprains and physical therapy and posture exercises. The operative treatment is complete removal of the meniscus. The quadriceps muscle should be used soon after operation.

Carr and Haggart⁴⁷⁸ present a program for the conservative management of the injured knee. The patient is put to bed and the knee supported with a pillow splint. If the injury has occurred within four to six hours, the knee should be packed in ice bags. A large effusion that occurs immediately is usually due to hemorrhage. After twelve to twenty-four hours, aspiration of the joint fluid is wise. Active exercises for the quadriceps muscle are commenced on the second or third day and increased as conditions permit. In any injury of the knee, full weight bearing should not be permitted for several weeks and crutches

476 Seley, G. P. Traumatic Popliteal Aneurysm, Obliterative Endoaneurysmorrhaphy, End Result, *J Mt Sinai Hosp* 10:738 (Jan-Feb) 1944.

477 Allan, J. H., and Nicholson, J. T. Knee Injuries in Service Personnel, *U S Nav M Bull* 43:63-72 (July) 1944.

478 Carr, C. R., and Haggart, G. E. Treatment of Acute Knee Injuries, with Special Attention to the "Weak Knee" Syndrome, *U S Nav M Bull* 42:787-797 (April) 1944.

should be used for four to six weeks. Swimming should be allowed fairly early.

Batchelor⁴⁷⁹ reviews 109 cases of internal derangement of the knee joint. He found evidence of injury of the cruciate ligament in 33 per cent of the cases. He discusses the functional anatomy of the cruciate ligaments and stresses the point that when the leg is in full extension no pathologic movement is possible if only one cruciate ligament is damaged, because of the action of the collateral ligaments. With the knee in flexion, cruciate damage allows increased abduction, adduction and gliding. The diagnosis is made on the basis of pain, swelling and weakness and the history of an injury. The drawer sign is best elicited when the leg is flexed to an angle of 20 to 25 degrees. Batchelor advises the routine examination of the knee under anesthesia. By way of treatment, he says that meniscectomy should not be performed unless true locking is present. For recent complete tears of the anterior cruciate ligament he advises immobilization for eight to ten weeks with the leg flexed at an angle of 10 to 15 degrees. Sprained knees are immobilized for four to six weeks. Fractures of the tibial part of the spine are immobilized in full extension. Moderate laxity of the cruciate ligaments may be treated by physical therapy, including exercises for the quadriceps and hamstring muscles. He attempted no surgical repair.

Abbott, Saunders, Bost and Anderson⁴⁸⁰ stressed the frequency of occurrence of ligamentous injuries of the knee joint and say that the indefinite diagnosis of "internal derangement" is made too frequently. One must establish an accurate anatomic diagnosis and use specific therapy rather than "rest and fixation" in all cases. Their article contains an excellent consideration of the functional anatomy of the knee joint and its ligaments. They point out that the common mechanisms of injury are abduction alone and abduction combined with flexion and rotation. Objectively, local tenderness, hemarthrosis and abnormal mobility were of constant occurrence. Abduction rocking to a pronounced degree is indicative of injury to the tibial collateral and anterior cruciate ligament. Prompt and complete repair of the tibial collateral ligament is advocated in such cases.

[ED NOTE—This is an excellent article, which should be read by all surgeons interested in injuries of the knee joint.]

479 Batchelor, J. S. Tears of the Cruciate Ligaments in Internal Derangement of the Knee, from a Study of One Hundred and Nine Consecutive Cases of Injury to the Knee-Joint, *Guy's Hosp. Rep.* **92** 60-67, 1943.

480 Abbott, L. C., Saunders, J. B., deC. M., Bost, F. C., and Anderson, C. E. Injuries to the Ligaments of the Knee Joint. *J. Bone & Joint Surg.* **26** 503-521 (July) 1944.

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Dislocation—Sever ⁴⁸¹ reports 2 cases of dislocation of the knee joint. In the first, a 47 year old carpenter had an anterior dislocation. Follow-up data showed no evidence of any injury to the semilunar cartilages, and there was no evidence of instability due to injury of the crucial ligaments. In the second case, a 39 year old man had a posterior medial dislocation which extended into the popliteal space through a wound. There was periosteal stripping of the end of the femur. Examination a year later showed slight lateral instability or increased motion in the joint. There was no evidence of any injury of the semilunar cartilages of crucial ligaments, and in spite of the extensive trauma no injury of the nerves or vessels had been sustained.

Baumann ⁴⁸² discusses the surgical exploration of the injured knee joint. He notes that the posterior surface of the patella should be examined for chondromalacia, a frequent complication. He also notes that a protruding and darkened region at the medial condyle of the femur indicates a rupture of the posterior cruciate ligament.

Semilunar Cartilages—Smillie ⁴⁸³ reviews the literature on regeneration of cartilage and reports that subsequent operation was necessary in 600 cases in which meniscectomy had been performed. He says that if the entire meniscus is excised a new one grows from the parietal synovial membrane and that it has the same appearance as the old one but that it has a dense capsular attachment with no line of cleavage. It is thinner and narrower than normal and is composed of fibrous tissue only. If the anterior half or two thirds is excised, the excised portion is replaced by fibrous tissue with the features that have just been noted. The author favors total meniscectomy, as the most nearly perfect replication follows this type of operation. Injury to the regenerated meniscus is possible only with gross instability of the knee joint.

Duthie and Macleod ⁴⁸⁴ summarize the results of removal of one or more semilunar cartilages in 179 soldiers. Seventy-five per cent of the soldiers were placed in a 1-A category as the immediate result of rehabilitation at a convalescent depot. A review of results six months to one year after the soldiers returned to active duty shows that of the 1-A group on discharge from the depot 27 had to be placed in a lower

481 Sever, J. W. Dislocation of the Knee Joint. A Report of Two Cases, *New England J. Med.* **231** 318-319 (Aug. 31) 1944.

482 Baumann, E. Seltener Binnenschäden im Kniegelenk, *Schweiz. med. Wchnschr.* **73** 435-437 (April 10) 1943.

483 Smillie, I. S. Observations on the Regeneration of the Semilunar Cartilages in Man, *Brit. J. Surg.* **31** 398-401 (April) 1944.

484 Duthie, J. J. R., and Macleod, J. G. Meniscectomy in Soldiers. Review of Cases Discharged from an Army Convalescent Depot, *Lancet* **1** 182-183 (Feb. 5) 1944.

group, while of those in categories below 1-A, 61 per cent remained in the same category and 39 per cent were classified in a lower category after their discharge. The criteria for discharge from the depot in a 1-A category were a strenuous course of physical training, a 3 mile (4.8 kilometer) cross country run and a 15 mile (24.1 kilometer) route march, without reaction in the knee. It was suggested that minor degrees of instability of the knee, possibly due to laxity of the anterior cruciate ligament, may persist after meniscectomy. In the absence of regular exercises for the quadriceps muscles this instability may result in a disability.

Cleveland, Willien and Doran⁴⁸⁵ analyze the results of seventy-five operations on the knee joint of soldiers, to determine whether or not elective operation on the knee joint is worth while from a military standpoint. Forty-six per cent of the soldiers were rehabilitated to a full duty status, 43 per cent were reclassified for limited service after operation, 47 per cent were reclassified for limited service prior to operation, and 63 per cent were discharged for disability. In cases of tear of the medial meniscus, which is the most frequent internal derangement encountered, 44.8 per cent of the soldiers have been returned to full duty after operation. Patients with cysts of the medial and lateral menisci have been rehabilitated to full duty in a high percentage of cases. In 50 per cent of the cases of osteochondritis, the patients have returned to full duty. All patients with intra-articular fractures and all with injuries involving both menisci have been reclassified for limited service or discharged from the army. The authors stress the importance of the removal of the entire meniscus.

Osteochondritis Dissecans—Stein, Ikms and Lowry⁴⁸⁶ classify osteochondritis dissecans into three types according to the symptoms: (1) sudden and severe, (2) chronic and (3) asymptomatic. They review the etiologic theories and say that the traumatic theory is the most acceptable.

Strange⁴⁸⁷ defines osteochondritis dissecans as a localized aseptic necrosis of cartilage and underlying bone. He reports a case in which the disease involved the lateral condyle of a 4½ year old boy but cleared up with conservative treatment in a cast.

485 Cleveland, M., Willien, L. J. and Doran, P. C. Surgical Treatment of Internal Derangement of the Knee Joint Among Troops in Training at Fort Jackson, South Carolina. An End-Result Study. *J. Bone & Joint Surg.* **26**: 329-336 (April) 1944.

486 Stein, G. H., Ikms, R. G., and Lowry, F. C. Osteochondritis Dissecans. *Am. J. Surg.* **64**: 328-337 (June) 1944.

487 Strange, T. B. Osteochondritis Dissecans. Case Report. *Am. J. Surg.* **63**: 144-145 (Jan) 1944.

[ED NOTE—Both of these articles emphasize again the fact that in some cases osteochondritis dissecans may heal spontaneously]

Synovial Membrane—Whalley⁴⁸⁸ reports a case of compression of the external popliteal nerve by a Baker cyst arising from the superior tibiofibular joint. Pain and foot drop were completely eliminated and full function was restored by removal of the cyst.

Tumors and Pseudotumors of Synovial Membrane—Milwidsky⁴⁸⁹ reports 2 cases of pseudotumor of the synovial membrane of the knee joint. In 1 case the lesion was a synovitis villosa hemorrhagica chronica, in the other it was a benign synovial histiocytoma. Both patients were treated by synovectomy. One is well eighteen months postoperatively, and the other is well six months postoperatively.

Cox⁴⁹⁰ reports a case of chondroma of a meniscus in a woman 54 years of age. Roentgenograms showed a lifting of the periosteum of the upper surface of the internal condyle of the femur with rarefaction beneath the periosteum, suggestive of a tuberculous lesion. Exploration of the knee joint revealed a white hyaline mass about the size of a walnut, lying loose in the joint, a similar mass had been formed from the anterior part of the medial meniscus. Both masses were removed and the pathologic report indicated that the two had the same microscopic structure and the appearance of a chondroma.

Steinsleger and Slullitel⁴⁹¹ report 2 cases of angioma of the knee joint. In 1 case the patient was a boy, 14 years old, in the other case the patient was a girl, 12 years old. The authors review the etiologic theories and point out that most authors agree that these tumors are congenital. They state that the treatment is always surgical and that the results are good in cases in which the tumor is localized.

Uhry⁴⁹² reports an unusual case of periarticular metaplastic formation of bone about the knee. A rapidly developing swelling, 3 inches (7.6 cm) in diameter, appeared over the head of the fibula. The mass was excised and found to contain "connective tissue spindle cells, with

488 Whalley, N. Compression of the External Popliteal Nerve by a Baker's Cyst, *Brit. J. Surg.* **31** 306-307 (Jan.) 1944.

489 Milwidsky, H. On the Occurrence of Pseudotumors in the Synovial Membrane of the Knee Joint, *J. Internat. Coll. Surgeons* **7** 227-233 (May-June) 1944.

490 Cox, L. W. Chondroma of a Meniscus of the Knee Joint, *Australian & New Zealand J. Surg.* **13** 199 (Jan.) 1944.

491 Steinsleger M., and Slullitel, I. Angiomas de la rodilla, *Rev. ortop. y traumatol.* **13** 3-14 (July) 1943.

492 Uhry, E., Jr. Pararticular Metaplastic Bone Formation About Knee, *Bull. Hosp. Joint Dis.* **4** 70-73 (Oct.) 1943.

direct osseous metaplasia in some areas and with osseous metaplasia through the mediation of chondro-osteoid in others" Seven months after operation there was no evidence of recurrence

Calcification of Articular Cartilages—Harmon⁴⁹³ reports 2 cases of calcification of the articular cartilages In 1 case, the clinical diagnosis was degenerative arthritis, in the other it was gout In both cases, roentgenographic examination disclosed calcification of the articular cartilages of the knee joint

Bursae and Bursitis—Voshell and Brantigan⁴⁹⁴ report 10 cases in which bursitis occurred beneath the tibial collateral ligament The diagnosis is based on the history, on the presence of pain and swelling anterior to the tibial collateral ligament and on the excision of the bursa or aspiration of bursal fluid with recovery from painful symptoms In excising the bursa, the ligament need not be severed and the joint does not need to be opened Recovery after excision is prompt and apparently complete Rest, application of heat and aspiration and injection of procaine hydrochloride should be tried If the results are unsatisfactory or if the symptoms recur, excision of the bursa is indicated

[ED NOTE—These authors have pointed out another clinical entity about the knee The recognition of this disease is important]

Burman⁴⁹⁵ reports 4 cases in which a semimembranous bursa resulted from injury of the internal meniscus He feels that trauma which tears the internal meniscus may also cause semimembranous bursitis This association emphasizes the need for examining the back of the knee in every case in which this joint is injured

Tenosynovitis—Conway⁴⁹⁶ reports 5 cases in which tenosynovitis of the patellar tendon developed in B-24 pilots after they had flown many hours with constant extension tension on the rudder control Strapping the patella upward gave immediate relief The author notes that measures should be taken by aeronautic engineers to lessen the load on the overworked muscles and tendons

493 Harmon, P H Degenerative Calcification in Articular Cartilage of Knee Differentiation from Calcification of Menisci, *J Bone & Joint Surg* **26** 838-840 (Oct.) 1944

494 Voshell, A F, and Brantigan, O C Bursitis in the Region of the Tibial Collateral Ligament, *J Bone & Joint Surg* **26** 793-798 (Oct.) 1944

495 Burman, M Semimembranosus Bursitis Association with Tear of the Internal Meniscus of the Knee Joint by Common Trauma, *J A M A* **124** 29-30 (Jan. 1) 1944

496 Conway, W H Acute and Chronic Suprapatellar Tenosynovitis and Fascitis in Pilots of Heavy Bombers, *Air Surgeon's Bull* (no 9) **1** 18 (Sept.) 1944

arthrosis or synovitis were found. The patient, who was 32 years old, did mountain climbing, played tennis and went skiing. The function of the knee was nearly perfect.

Du Bourguet and Sergent⁵⁰⁵ report a case of irreducible traumatic luxation of the patella. The lateral mobility of the patella was impaired, and the articular portion of the patella was in contact with the external surface of the external femoral condyle. A Fevre-Dupuis operation was performed. This consists in a parapatellar incision, detachment of the anterior tubercle and patellar ligament and freeing of adhesions. The tubercle was reattached about 2 cm above its primitive insertion, which allowed for flexion of the knee. Motion was begun twenty-one days after the operation. Six months later active flexion to 90 degrees was present, there was no swelling and the strength of the quadriceps muscle was good.

Humphries⁵⁰⁶ reports a case of intracondylar dislocation of the patella in which open reduction was employed. There was no apparent rupture of the quadriceps tendon or ligamentum patellae. This was in contrast with 6 cases reported by Cheesman in 1905, as injury to the quadriceps tendon or crucial ligament was present in all of these cases.

Loomis⁵⁰⁷ reports the use of cotton sutures in preference to wire to repair fractures of the patella. He notes that (1) there is no electrolytic activity, (2) the sutures may be tied rather than twisted and (3) the joint reactions which occur with wire do not occur with cotton.

Infection of the Knee—Fox and Gilbert⁵⁰⁸ report a case in which epidemic cerebrospinal (meningococcic) meningitis was associated with purulent arthritis of the knee. Treatment with sulfathiazole proved successful. The article contains a good review of the literature to date and a discussion of the types of arthritis liable to be associated with meningitis, including an early purpuric type, a metastatic infectious type and a late urticarial (serum reaction) type.

Knock Knees—Girdlestone⁵⁰⁹ describes a night splint which is easily made, easily understood and applied and comfortable. It consists of two tapering gutter splints riveted back to back and suitably padded.

505 Du Bourguet and Sergent. Luxation traumatique irréductible de la rotule, operation di Fevre et Dupuis, *Mém Acad de chir* **68** 406-409 (Nov 11-18) 1942.

506 Humphries, S. V. Intercondylar Dislocation of the Patella, *South African M J* **17** 347-348 (Nov 27) 1943.

507 Loomis, L. K. Internal Fixation of Fractures of the Patella with Cotton Suture Material, *Surgery* **15** 602-605 (April) 1944.

508 Fox, M. J., and Gilbert, J. Meningococcus Infections with Articular Complications, *Am J M Sc* **208** 63-69 (July) 1944.

509 Girdlestone, G. R. Night Splint for Knock-Knees. *The Mermaid, Lancet* **1** 312 (March 4) 1944.

The children take to the application of this splint readily. The splint need be worn only at night and is, of course, used in addition to "wedged heels" and the standard exercises.

Rehabilitation—O'Donnell⁵¹⁰ states that physical therapy of the knee is often inadequate because all muscles of the hip, knee and ankle must be given attention. He stresses the importance of exercises of the vastus medialis muscle. Physical therapy is most effective when employed frequently and for short periods. Fatigue should be avoided, and heat should not be used more than fifteen to twenty minutes at one time.

XVI Conditions Involving the Elbow, the Forearm, the Wrist and the Hand

PREPARED BY WALTER P BLOUNT, M D, MILWAUKEE

Elbow—An unusual case of radiohumeral synostosis is reported by Frankel⁵¹¹. The patient died of nephritis at the age of 23, and a postmortem examination was obtained. The radius was firmly ankylosed to the humerus. The ulna was rudimentary. The arms were symmetrically short and atrophic.

No similar deformity had occurred in the parents or in members of their families, who were healthy and prolific. There were 7 siblings, 4 with the same deformity. One sister died at 10 years, after a tonsillectomy. She probably had renal disease. A 19 year old brother had the identical deformity. He was apparently normal otherwise, but laboratory studies showed gross deficiency in renal function. A sister, aged 16, had the same deformity. She was 1 of twins, the other being a normal boy. There was no evidence of renal disease.

In all the affected persons, there was absence or abnormality of one or both patellas. Frankel observed that both parents, who were normal, must have had the same recessive trait. The deformity must have developed during the first three months of fetal life.

March⁵¹² describes a case of osteochondrosis of the capitellum similar to coxa plana in the hip. The subject of osteochondroses is briefly reviewed. Involvement of the capitellum was apparently first described by Paner in 1927. March suggests calling this entity "Paner's disease". The patient in this case was 8 years old. Sudden limited flexion appeared after he threw a dart. Later, limitation of extension developed. Motion of the elbow was free and painless.

510 O'Donnell, E D. Rehabilitation of Knee Injuries, *Physiotherapy Rev* **24** 100-103 (May-June) 1944

511 Frankel, E. Humeroradial Synostosis, *Brit. J Surg* **31** 242-245 (Jan) 1944

512 March, H C. Osteochondritis of the Capitellum (Paner's Disease), *Am J Roentgenol* **51** 682-684 (June) 1944

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through a limited range Pronation and supination were not disturbed There was slight swelling, particularly over the lateral aspect, but no redness Roentgenograms which are submitted show irregularity of density with some increase in density and slight irregularity of outline The symptoms disappeared with a few weeks' rest

[ED NOTE—A disturbance of osteochondral growth has certainly been observed at every growth center in the body The common ones are well recognized It is important to record examples of the rarer locations Priorities are difficult to establish It is questionable whether proper names should be attached to the unusual lesions, there are many epiphyses, and to use as many proper names would be confusing and undesirable It is better to designate the lesion as osteochondrosis of a certain location]

A new conception of olecranon bursitis ("tennis elbow") is offered by Allen,⁵¹³ of Sydney, Australia In 7 cases in which the symptoms were brought on by strain or contusion, complete relief was obtained by excising the synovial membrane from the lateral side of the radio-humeral joint In each case, thickened synovia was said to be found It is Allen's contention that the essential pathologic change lies in a 'synovial fringe,' the nipping of which is responsible for symptoms in a manner similar to that in which the nipping of a semilunar cartilage may cause symptoms in the knee joint He recommends excision of the tag of synovial membrane in troublesome cases

[ED NOTE—An operative attack on the lateral aspect of the radiohumeral joint would involve freeing fibers of the extensor muscles of the forearm from the epicondyle This is a well recognized method of curing obstinate epicondylitis Whether the relief of symptoms was caused by the removal of the synovial fringe or by the subsequent scarring of the extensor muscles at their origin is debatable in the cases submitted]

In a review of disabilities of the elbow in cases of air hammer injury, Fuss⁵¹⁴ found 75 instances of fissure formation, which he compares with the fatigue fractures of bones elsewhere There were 22 fissures of the tip of the coronoid process and 15 of the tip of the olecranon exclusive of 24 cases of fracture of a bony spur in the triceps tendon He reports isolated cases of fractures of exostoses elsewhere Fuss observes that after prolonged use of pneumatic tools there is often degenerative change of the elbow joint This is frequently an extensive degenerative arthrosis Often the fissures have

513 Allen, J. C. B. Epicondylitis Traumatic Radio-Humeral Synovitis, *M. J. Australia* 1 273-274 (March 25) 1944

514 Fuss, H. Fissure Formation in Region of the Elbow Joint Due to Use of Pneumatic Tools, *Zentralbl. f. Chir.* 70 481 (April 3) 1943

been observed in osteophytes. Sometimes they have been in normal bone. The presence of fissures does not constitute a reason for discontinuing the use of pressure tools. The degree of arthrosis, and not the presence of fissures, is the criterion as to extent of damage to the joint.

From a wealth of material of 35 chronic dislocations of the elbow with and without fracture Allende and Freytes⁵¹⁵ review the pathologic changes and suggest surgical treatment. They conclude that the dislocation which has not been reduced after twenty-one days should be treated by open, and not closed, reduction. In such cases, they found massive bone production posteriorly between the periosteum and the humerus, frequently also of the anterior capsule. As early as two or three months after injury, scar tissue filled the olecranon fossa and the sigmoid cavity and covered the lower end of the humerus. Contracture of the triceps is troublesome and sometimes makes suture of the wound difficult. After six months, degenerative change of the articular surface makes arthroplasty preferable to open reduction.

Through a posterior approach with a step tenotomy of the triceps muscle (in 2 cases with transverse division of the olecranon), the joint was exposed. The ulnar nerve was freed and retracted. The fibrous tissue in the joint was removed by sharp dissection. The elbow was then flexed. The radiohumeral "horn" and all other adventitious ossifications were removed, along with other structures which interfered with normal motion. The elbow was then reduced. The ulnar nerve was replaced and the wound closed. A cast was applied with the elbow flexed to 140 degrees unless this instability required more flexion. In the earlier cases, extension was limited because the elbows had been fixed at right angles. The cast was removed and motion was started on the tenth day.

End results are not reported because only 14 cases could be followed. In those the elbow was stable and painless, with movement between 40 and 120 degrees.

In flexion contracture of the elbow following fracture, Philip D. Wilson⁵¹⁶ has performed a capsulectomy, with pronounced improvement of function. He outlines the operative technic, which is well illustrated by diagrammatic drawings. He summarizes 7 cases.

Hass⁵¹⁷ reports 15 cases of arthroplasty of the elbow in which the technic is modified according to his method of producing a sharp wedge

⁵¹⁵ Allende, G., and Freytes, M. Old Dislocation of the Elbow, *J. Bone & Joint Surg.* **26** 691-706 (Oct.) 1944.

⁵¹⁶ Wilson, P. D. Capsulectomy for the Relief of Flexion Contractures of the Elbow Following Fracture, *J. Bone & Joint Surg.* **26** 71-86 (Jan.) 1944.

⁵¹⁷ Hass, J. Functional Arthroplasty, *J. Bone & Joint Surg.* **26** 297-306 (April) 1944.

at the tip of the proximal fragment and a shallow groove on the end of the distal bone. Recurrent ankylosis occurred in 3 cases.

A curved incision, convex downward, is made around the olecranon, which is chiseled off obliquely along with the attachments of the triceps tendon. The ulnar nerve is dissected out of its sulcus and retracted medially. The synostosis is then broken through by means of chisel and mallet, the lateral ligaments being preserved as carefully as possible. The distal end of the humerus is formed into a sharp wedge, while the ulna is reshaped to resemble a shallow trough. If there is also a radioulnar fusion, it is broken up and the head of the radius is either formed into a wedge directed toward the ulna or resected entirely. The scarred capsular tissues are then removed, the bleeding is controlled and the bone ends are smoothed off by means of rasp and mallet. The end of the humerus is covered with a flap of fatty tissue taken from the thigh and fastened to the humerus with surgical gut. At this stage, to facilitate extension, the bony tip of the olecranon is removed from the triceps tendon, and the latter is fixed to the periosteum of the ulna with silk. The skin is closed and skin traction incorporated in a plaster cast for three weeks, with the elbow in extension and the forearm in slight supination.

[Ed. NOTE—From the submitted roentgenograms, it would appear that the procedure is more like a resection than an arthroplasty. This fact does not detract from its usefulness.]

Berntsen⁵¹⁸ reports a similar procedure, which he terms "arthroplastic resection."

Wrist—Successive stages in the elaboration of the transverse carpal arch were studied in a comparative examination of Amphibia and Reptilia and Mammalia by Hughes⁵¹⁹. Outline drawings of the cross section through the carpal canal show that there is little indication of transverse arching of the carpus in forms below the primates. The arch reaches its highest development in the anthropomorphous apes and man, and in them it is associated with a single cavity wrist joint capable of extensive abduction-adduction movement. The function of the arch seems to be to stabilize the carpal tunnel, in which the flexor tendons lie.

Far from being an insignificant sesamoid, the pisiform bone has been shown by Harris⁵²⁰ to be analogous to the calcaneus in the foot.

518 Berntsen, A. Arthroplastic Resection for Ankylosis of the Elbow, *Ugeskr. f. læger* **105** 441 (May 6) 1943.

519 Hughes, H. The Evolution and Functional Significance of the Transverse Carpal Arch of Man, *J. Anat.* **78** 167-172 (Oct.) 1944.

520 Harris, H. A. The Pisiform Bone, *Nature*, London **153** 715 (June 10) 1944.

An extensive analysis of the roentgenograms of the carpus in various mammals has shown that the pisiform is a true carpal bone. In all the young primates with the exception of man there is a secondary bone center, as in the calcaneus with a well marked epiphysal growth cartilage. An illustration is submitted in which the lateral roentgenogram of a young *Macacus rhesus* monkey is shown. The pisiform actually looks like a calcaneus in this picture and has an apophysis closely simulating that of the calcaneus.

[ED NOTE—The discovery of the analogy between the pisiform in the wrist and the calcaneus would seem to have great significance in comparative anatomy. It should also dignify the pisiform in the eyes of orthopedic surgeons.]

As an accidental finding, White⁵²¹ discovered a congenital bilateral fusion of the capitate and hamate bones. These structures were represented by one large, undifferentiated bone. Roentgenologic examinations of the wrists of the parents revealed nothing abnormal.

Aseptic necrosis of various bones of the wrist was reported during the year. Jonsson⁵²² cites a case of progressive malacia of the os capitatum in a 22 year old nurse. There was no predisposing injury or illness. Occasional swelling, with weakness and pain, was observed. After six months, crepitation was noted. The sedimentation rate was normal. The roentgenographic appearance was analogous to that of osteochondrosis of the lunate bone (Kienbock's disease). A similar condition of the navicular was reported by Stack,⁵²³ who calls it "Preiser's disease" because Preiser reported such a case in 1910. It occurred in a 43 year old white man. There was a gradual onset of rheumatic pain, aggravated by bowling and casting. There was weakness of grip but no swelling except for fulness in the anatomic snuffbox. There was tenderness over the scaphoid bone, most noticeable in the snuffbox. There was slight limitation of flexion and extension of the wrist with pain on extremes of motion. Serial roentgenograms showed gradual fragmentation and absorption of the bone.

Similar involvement of the metacarpal bones and the phalanges in a 22 year old farm hand was reported by Franck.⁵²⁴ The onset appeared when the patient was 14 without apparent cause. The first symptom

521 White, E. H. Bilateral Congenital Fusion of the Carpal Capitate and Hamate. *Am J Roentgenol* **52** 406-407 (Oct.) 1944.

522 Jonsson, G. Aseptic Bone Necrosis of the Os Capitatum (Os Magnum). *Acta radiol* **23** 562-564 1942.

523 Stack, J. K. Preiser's Disease. Aseptic Necrosis of the Carpal Navicular. *Quart Bull Northwestern Univ M School* **18** 44-45 1944.

524 Franck, S. Aseptic Necrosis in the Epiphyses of Digital Phalanges and Metacarpal Bones (Thiemann's Disease, Dietrich's Disease), *Acta radiol* **23** 449-454 1942.

Boyd and Stone⁵³⁰ emphasize the value of resection of the distal end of the ulna in cases of traumatic Madelung deformity. The procedure is of special value in restoring or increasing pronation and supination in the distal radioulnar joint. It relieves pain caused by arthrosis of this joint. It corrects deformity of the wrist.

Removal of the distal end of the ulna does not materially affect the strength and stability of the hand or the wrist. If the contours are normal, they are little changed by the procedure. If there is deformity due to radial shortening, the cosmetic appearance is greatly improved. The operative technic is described and 5 cases reported in detail.

Tendon transplantation according to the method of Perthes was performed by Stumpfegger⁵³¹ in 26 cases of war injuries of the radial nerve. The nerve was totally lost in 18 cases, and the typical Perthes' operation was used. This consisted in the transplantation with the sheath of the flexor carpi ulnaris muscle and flexor carpi radialis muscle to the dorsal flexor muscles. A tenodesis of the extensor carpi ulnaris and extensor carpi radialis muscles is used to maintain dorsiflexion of the wrist of 30 degrees. Stumpfegger emphasizes the need for blunt dissection to free the muscles widely before they are transplanted through broad tunnels. It is important also to obtain the correct tension on the transplanted tendon. This is not easy because of frequent degenerative changes in the affected region. The problem is discussed in the light of Gebhardt's explanation of the loss of tonus.

In 8 cases, only a partial operation was necessary. In 3 cases a tenodesis was not necessary. In 3 cases, only the extensor and abductor muscles of the thumb were involved and in 2 cases only the extensor muscle of the fingers.

Hand—Anomalies of Muscles. Cirio and Mansi⁵³² report an anomalous second attachment of the abductor longus muscle of the thumb. The second slip contained a fleshy belly which lay volar to the abductor brevis muscle. It ended in a small tendon which attached just radial to the abductor brevis. They also report⁵³³ a muscular slip on the dorsum of three out of fifty-two hands examined, or in 6 per cent of the cases. The percentage has been given by other authors

530 Boyd, H. B., and Stone, M. M. Resection of the Distal End of the Ulna, *J. Bone & Joint Surg.* **26** 313-321 (April) 1944.

531 Stumpfegger, L. Experiences with the Perthes Substitution Operation for Radial Nerve Paralysis, *Chirurg* **15** 430 (July 15) 1943.

532 Cirio, J. J. and Mansi, D. Anomaly of the Abductor Pollicis Longus, *Arch. Soc. argent. de anat. norm. y pat.* **4** 171-173 (May-Sept.) 1942.

533 Cirio, J. J. and Mansi, D. Three Examples of an Anomalous Muscle on the Dorsum of the Hand, *Arch. Soc. argent. de anat. norm. y pat.* **4** 251-254 (May-Sept.) 1942.

as 24 and 85 per cent. The muscle slip lay on the dorsum between the long extensor tendons. In 1 case, there was an attachment to the second and third extensor tendons, with absence of the extensor proprius muscle of the index finger. In the other 2, the attachment was to the extensor muscle of the middle finger and the aponeurosis over the third metacarpophalangeal joint.

[ED NOTE—It is important to remember that muscular as well as bony anomalies do occur in the hands as well as the feet. Better knowledge of the more frequent anomalous structures would occasionally save embarrassment.]

Reimann and colleagues,⁵³⁴ in an anatomic study of the palmaris longus muscle and tendon from one thousand, six hundred extremities, encountered complete absence in 205 (12.9 per cent) of the cases. Bilateral absence was encountered more frequently than absence on either the right or the left. Numerous variations in position and form are described and illustrated. There may be an accessory palmaris longus muscle with the tendon proximal and the muscle belly distal. The same relations may obtain in a single normally placed tendon. The muscle belly may be centrally placed. The muscle or the tendon may be bifid. The tendon alone may be divided, with an ulnar slip inserting into the antibrachial fascia.

From a study of one hundred and fifty consecutive upper extremities by Dykes and Anson,⁵³⁵ it appeared that the accessory tendon of the flexor pollicis longus muscle is present more frequently than it is absent. In addition to its normal or its main origin from the radius and interosseous membrane (which were invariably present), an origin from the humerus is almost always present. An additional one from the ulna occurs in about one half of the cases. Eighty extremities possessed accessory origins, which were present bilaterally in twenty-seven cadavers. The regular skeletal origin of the elongate tendon was found to be the medial epicondyle of the humerus. The medial side of the coronoid process of the ulna offered secondary bony origin in 11 cases and the coronoid process alone in 1 specimen. Invariably the tendon also attached to the capsule of the elbow joint.

Haines⁵³⁶ emphasizes the importance of some unappreciated ligaments at the base of the first metacarpal bone. He shows that their function is a guiding one during axial rotation of the first metacarpal

534 Reimann, A. F., Daseler, E. H., Anson, B. J., and Beaton, L. E. The Palmaris Longus Muscle and Tendon. A Study of 1,600 Extremities, *Anat. Rec.* 89: 495-505 (Aug.) 1944.

535 Dykes, I., and Anson, B. J. The Accessory Tendon of the Flexor Pollicis Longus Muscle. *Anat. Rec.* 90: 83-87 (Sept.) 1944.

536 Haines, R. W. The Mechanism of Rotation at the First Carpometacarpal Joint. *J. Anat.* 78: 44-46 (Jan.) 1944.

bone This motion takes place at the end of the movements of flexion and extension of the first carpometacarpal joint

The anatomy of the thumb has been subject to new studies by Sunderland,⁵³⁷ who describes the elevation of the hypothenar eminence in opposition of the thumb to the little finger This produces a rounded contour or arch of the palm, which is lacking in lesions of the ulnar nerve In this injury to the nerve it is the paralysis not only of the opponens pollicis muscle but also of the opponens digiti quinti muscle which disables the patient This fact suggests a new test for ulnar nerve palsy the persistent flatness of the dorsum of the hand on the affected side when opposition of the thumb and the little finger is attempted

Sunderland's succeeding article⁵³⁸ summarizes a series of 12 cases in which there was complete loss of power of the long flexors of the thumb It was still possible to flex the distal phalanx of the thumb by a trick movement This consisted in extension-abduction of the thumb while the wrist was dorsiflexed He calls attention to the fact that in using flexion of the tip of the thumb as a test for the integrity of the median nerve the thumb must be held inside of the plane of the index finger

Flexor Tendon Injuries—In the face of the general pessimism with regard to flexor tendons which are cut in the digital sheath, Koch⁵³⁹ stoutly maintains that good results can be secured if conditions are favorable and if the surgeon is willing to expend sufficient time and patience He points out that painstaking attention to detail is necessary Trauma to delicate tissues must be avoided if healing with little inflammatory reaction is to be obtained The operating time may be as long as five hours For success, it is essential to have (1) fingers with an adequate blood supply and free from excessive scar tissue formation, (2) sufficient tendon with a smooth uninjured synovial covering, (3) a retentive mechanism, to hold the tendon in contact with the volar surface of the finger when tension is put on it and (4) normal mobility at the interphalangeal and the metacarpophalangeal joints

If the available tendon is irreparably damaged, one must provide a substitute by one of two methods The sublimus tendon may be divided through a transverse incision just above the wrist and drawn

537 Sunderland, S The Significance of Hypothenar Elevation in Movements of Opposition of the Thumb, *Australian & New Zealand J Surg* **13** 155-156 (Jan) 1944

538 Sunderland, S Flexion of the Distal Phalanx of the Thumb in Lesions of the Median Nerve, *Australian & New Zealand J Surg* **13** 157-159 (Jan) 1944

539 Koch, S L Division of the Flexor Tendons Within the Digital Sheath *Surg Gynec & Obst* **78** 9-22 (Jan) 1944

out through the palmar incision. One or two of the long extensor tendons from the lateral four toes may be removed without loss of function of the toes. Either of these may be substituted for the profundus. Unless the retentive annular ligament is preserved or can be repaired, it must be replaced by slip of normal tendon which is passed around the finger to form a new annular ligament.

It is obviously impossible to complete a successful tendon repair if the mobility of the joint is limited. Often the first step in treatment of a patient with an injured flexor tendon is physical therapy to secure increased mobility and restore passive flexion at the interphalangeal and metacarpophalangeal joints.

The details of locating incisions, mobilizing divided tendons and grafting tendons are reviewed. Koch has not given up the use of silk sutures. He is reluctant to use steel wire and unwilling to use the "pull-out" stitch of Bunnell. The important details of technic are emphasized. It is necessary to close the distal incision before completing a tendon graft, particularly in the case of a thumb. The graft must be long enough to extend well above the wrist so that the pull on the suture line will be in a straight line.

The wrist must be splinted in flexion and the elbow held flexed with a sling for six or seven days. During the second and third weeks, the dressings are changed at three to four day intervals and stitches removed without disturbing the position. Active movement is begun at the end of the third week without permitting relaxation of the flexed fingers and hand. At the end of three and one-half or four weeks, some relaxation is permitted. During the postoperative period, relaxation of the tendons is obtained by sharp flexion of the wrist and moderate flexion of the metacarpophalangeal joints but never by flexion of the fingers at the interphalangeal joints.

A summary of the end results of 46 cases of flexor tendon injury over a three year period is submitted. Koch concludes:

If the surgeon is willing to exercise care to avoid trauma to vulnerable tissues, and the patience that is required for a tedious operation and for painstaking care during the postoperative period, and if the patient is willing to co-operate with a skillful physical therapist when the necessary period of immobilization is completed good results can be obtained after division of the flexor tendons within the digital sheaths.

The same subject is discussed succinctly by Bunnell⁵⁴⁰. He says that primary suture between the distal crease of the palm and the middle flexion crease of the finger fails the world over. The tendons become bound in adhesions because the tunnel is narrow and firm,

⁵⁴⁰ Bunnell, S. Primary and Secondary Repair of Flexor Tendons of the Hand, *Tr Am Soc Plastic & Reconstructive Surg* **12** 65-67 1943

so that the tendon ends swell in the process of repair, with loss of circulation, necrosis and then binding fibrosis. Silk sutures contribute to the reaction. The results are improved by splitting the annular ligament or pulley laterally to allow for swelling. Stainless steel sutures should be substituted for silk. After three weeks, when the tendon ends are physiologically united, stainless steel "pull-out" sutures may be removed. The suture that irritates the least is the one that is not there. Since the muscle pulls from only one end, the suture need be placed in only one end. It may be placed in the palm at a distance from the site of the laceration. The tendon ends are merely laid together or apposed with one fine silk strand. The wrist is held in flexion with a plaster splint and the "pull-out" suture brought out through the skin at the distal palmar fold, where it is fastened to a button. Motion is started in three weeks. Earlier exercise irritates and provokes adhesions. If the profundus tendon is divided in the fork of the sublimis tendon, the latter should be removed or the two will adhere to each other and so move only the middle joint.

In secondary suture the superficial and deep cicatrix must be excised and replaced with a pedicle skin graft when necessary. This provides the all-important nutrition. Before tendons can function, nerves must be repaired and malunited bones corrected. Carefully chosen incisions avoid the pernicious median-longitudinal scar. The incision should parallel flexion creases, never crossing them at or near a right angle. They should be planned to be remote from tendon repair. When the tendon is dropped back into scar tissue, it will readhere unless a sliding graft of fascia or paratenon fat is interposed. If this is not available, a free graft of paratenon fat from over the triceps tendon or just in front of the fascia lata on the outside of the thigh is used. Deep fascia from the forearm or from the thigh may be used with the smooth side toward the tendon. When a tendon graft is used, its surrounding epitenon may be sufficient to allow gliding. Tendon junctures should be placed where they will do the least harm, as at the distal phalanx of a finger and in the proximal part of the palm. In supplying a new tendon to a hand, the aim should be to make a minimum of moving parts and a maximum of gliding material.

Jones's report⁵⁴¹ of suture of flexor tendons of fingers, which was successful in 3 cases and partially successful in 6 more, emphasizes two points. It is necessary to excise a portion of the sublimis tendon to prevent adhesions between the two tendons. If this is not done, the distal joint will not flex. The tendon sheath must be cut away above and below the laceration. Jones has found it helpful to operate

⁵⁴¹ Jones R M. Successful Suture of Finger Flexor Tendon, *Lancet* 2 111 (Jul 22) 1944.

again, three or four months later, to break down adhesions by blunt dissection

In cases of persistent interphalangeal dislocation, Capurro and Russi⁵⁴² suggest the use of a strip of fascia to maintain the reduction. This is passed dorsal to the middle phalanx but volar to the extensor tendon. It is then brought around the volar surface of the distal end of the proximal phalanx, crossed and brought on either side of this phalanx to the extensor tendon, where it is sutured. A pull on the extensor tendon thus tends to maintain the position rather than to redislocate the finger.

The syndrome of pain, coldness and discoloration of one or more fingers of the dominant hand is reported in 11 cases by Barker and Hines⁵⁴³. In these farmers and mechanics, there was local arterial occlusion without arteriosclerosis, cervical rib, scalenus syndrome or occlusive arterial disease elsewhere. It appeared to the writers that the occlusion was the result of chronic occupational arterial trauma. Two of the patients used vibrating tools. Two were not smokers.

XVII Amputations, Apparatus and Technic

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UNDER the main headings in this review, one hundred and fifty articles were listed in the "Quarterly Cumulative Index Medicus," but, largely because of war time conditions, thirty-eight publications were not obtainable, only one hundred and twelve articles being left to be actually reviewed. However of the total number listed, forty-two, or 38 per cent could be classified under the general heading of amputations, this fact showing what an influence the war had over current medical literature during the year the conflict was at its height.

Amputations—Of the group of articles on amputation, sixteen, or over one third of the total number had to do with the use of refrigeration, this figure indicating that a decided trend seems to be in that direction or at least that there continues to be much interest in this increasingly popular means of obtaining sufficient anesthesia for amputations.

Most of the authors writing on the value of refrigeration in amputations emphasize the lowered mortality and diminished shock, citing

542 Garcia Capurro R and Russi, J C Persistent Interphalangeal Dislocation Arch urug de med cir y especialid **23** 134-137 (Aug) 1943

543 Barker N W and Hines E A Jr Arterial Occlusion in the Hands and Fingers Associated with Repeated Occupational Trauma Proc Staff Meet, Mayo Clin **19** 345-349 (June 28) 1944

its particular value in patients debilitated by vascular disease, initiated so frequently by diabetes

More and more, the appreciation of exact surgical procedures in amputations is apparent together with closer cooperation of the amputator with the artificial limb maker. This is particularly emphasized by Thomas⁵⁴⁴ in a well written article that deserves reading in full. In a British publication, Cohen⁵⁴⁵ writes along the same line, dwelling especially on the lowered mortality.

Two articles have appeared in which investigations as regards the tolerance of tissue to direct contact of ice on the skin are reported. Safford and Nathanson⁵⁴⁶ have written a most exhaustive article on the effect of difference in temperature as well as actual cold, on limbs. They found that in an arthritic patient with an extremely painful knee no apparent damage was done in keeping the temperature of the skin of the knee down to 60 F by Therm-O-Rite fluid. The patient, within a few hours of the application of the cold, admitted complete relief from pain but did experience some temporary excess swelling of the joint.

It appears to us that the Therm-O-Rite apparatus with the alcohol-containing coils used in this experiment may be more exact, but the danger of excessive cold with this apparatus and the safety of cracked ice seem to outweigh its value, at least for clinical work. In the same article, the fact that it is the rapid change of surface temperature that produces cutaneous lesions of a similar nature, whether cold or heat is the agent, is discussed. The similarity of the lesions resulting from frostbites or burns is better understandable on this basis.

Gandy,⁵⁴⁷ in investigating temperature of the skin with direct application of cracked ice, states that it varies between 0.5 and 6 C and that frostbite need not be feared, as the freezing point of tissue is below 0 C.

Against the argument that ice is a safe refrigerant, Kirz⁵⁴⁸ reports a case of gas gangrene developing after refrigeration amputation, in which on culture of the ice anaerobic spores were consistently found. Even so, it is difficult for us to understand why infection occurred if

544 Thomas, A. Permanent Prosthesis, *J A M A* **124** 1044-1046 (April 8) 1944

545 Cohen, S. M. Amputation Under Ice Anesthesia, *Proc Roy Soc Med* **37** 232 (March) 1944

546 Safford, F. K., Jr., and Nathanson, M. B. Clinical Observations on Tissue Temperatures. Pathologic and Therapeutic Effects, *Arch Surg* **49** 12-22 (July) 1944

547 Gandy, J. R. Reduced Temperature in Surgery, *M Rec & Ann* **38** 720-722 (Jan) 1944

548 Kirz, E. Gas Gangrene After Amputation Under Refrigeration Anesthesia. Warning, *Brit M J* **2** 662 (Nov 18) 1944

the refrigerated limb had been properly prepared for operation and if ice bags, rather than cracked ice, were used after the amputation, as is his custom. This is the only article that has been reviewed in the literature up to date that has called attention to this menace, which, with proper precautions, can be avoided.

Fearing damage by the cold to tissue distal to the tourniquet, Large and Heinbecker⁵⁴⁹ advise that the amputation level be chosen above the refrigerated area. They state that as the patient has been benefited from the refrigeration and the elimination of the involved part from the circulation he can stand inhalation or spinal anesthesia. We feel that there is little to support this claim and if supplementary anesthesia is given the main value of refrigeration is not taken advantage of. Perlow⁵⁵⁰ has written a paper advising that the amputation be done above the tourniquet but well below the top level of refrigeration. As a practical point, after doing a small series of refrigeration amputations, we feel that adequate anesthesia above the tourniquet could hardly be counted on, even after many hours of direct exposure to cracked ice.

Richards,⁵⁵¹ possibly justifiably, also sounds a note of warning as regards the merits of refrigeration in cases in which amputation is not definitely decided on. He calls attention to the fact that while bacterial growth is retarded by refrigeration so also is normal tissue response to inflammation and that when the cooling is discontinued the inflammatory reaction may even be aggravated. He does admit that refrigeration is of value when amputation has been decided on.

Interesting and enthusiastic papers on refrigeration anesthesia have been written by Miyakawa,⁵⁵² Hallendorf and Winnett,⁵⁵³ Hinchey⁵⁵⁴ and many others, who do not bring out any new points.

O'Neil⁵⁵⁵ states that only two to two and one-half hours is needed to get adequate anesthesia, urges the use of a narrow tourniquet and decries the use of drains. These points are open to considerable ques-

549 Large, A., and Heinbecker, P. Refrigeration in Clinical Surgery, *Ann Surg* **120** 707-715 (Nov.) 1944

550 Perlow, S. Refrigeration Anesthesia in Leg Amputation, *U S Nav M Bull* **42** 433-437 (Feb.) 1944

551 Richards, V. Refrigeration Anesthesia in Surgery, *Ann Surg* **119** 178-200 (Feb.) 1944

552 Miyakawa, G. Refrigeration Anesthesia with Special Reference to Treatment of Severely Damaged Extremity Complicated by Visceral Injury, *Am J Surg* **66** 384-386 (Dec.) 1944

553 Hallendorf, L. C., and Winnett, E. B. Shockless Surgery with Refrigeration Anesthesia, *J Iowa M Soc.* **34** 13-15 (Jan.) 1944

554 Hinchey, P. R. Refrigeration in Surgery of Extremities, *New England J Med* **230** 63-69 (Jan. 20) 1944

555 O'Neil, E. E. Use of Refrigeration in Amputation and Peripheral Vascular Disease, *New England J Med* **230** 209-216 (Feb. 24) 1944

tion in our opinion, and the interested reader is advised to refer to the original paper. If a reduction of the refrigeration time to two hours for adequate anesthesia can be obtained by the use of cracked ice, a decided advance in the technic has been achieved.

The Surgeon General of the Army⁵⁵⁶ has written an extensive history of the development of amputations from earliest times, which will be of much reference value for its bibliography, as well as for the text. In it he makes no attempt, however, to incorporate the advances made during this last war, nor in it does he include the discussion of chemotherapy, refrigeration anesthesia or other recent associated advances.

While admitting that the primary cause of painful stumps is in terminal neuromas, White⁵⁵⁷ admits that the possible origin occasionally is in the posterior central sensory association areas in the cerebral cortex. He advises only one excision of postoperative terminal neuromas. He has found that the only other procedures productive of relief have been sympathectomies and chordotomies. He considers the whole subject of painful stumps, in which there has been no relief from excision of neuromas, to be in the experimental stage. That is not much help to most surgeons confronted with these serious problems, but it is a satisfaction that a high authority is baffled.

In a somewhat similar article, Pisetsky⁵⁵⁸ writes of the importance of psychiatric factors in phantom limbs, substantiating White's opinions.

Following this lead, Gutierrez-Mahoney⁵⁵⁹ performed successfully a subpial resection of a portion of the sensory cortex corresponding to the amputated part. This seems heroic to us, but it at least solved the problem in one patient in a desperate condition.

Smith⁵⁶⁰ reports the danger of pathologic fractures, citing particularly a fractured femoral neck in a stump too energetically walked on after osteoporosis has followed prolonged involvement of the extremity ending in amputation. The moral of this is that amputees must not be too energetically urged to use excessively their involved extremity after long disuse.

556 Kirk, N. T. Development of Amputation, *Bull. M. Library A* **32** 132-163 (April) 1944.

557 White, J. C. Pain After Amputation and Its Treatment, *J. A. M. A.* **124** 1030-1035 (April 8) 1944.

558 Pisetsky, J. E. Phenomenon of Phantom Limb, *M. Bull. Vet. Admin.* **20** 320-323 (Jan.) 1944.

559 de Gutierrez-Mahoney, C. G. Treatment of Painful Phantom Limb by Removal of Post-Central Cortex, *J. Neurosurg.* **1** 156-162 (March) 1944.

560 Smith, N. Fracture of Neck of Femur After Amputation, *Brit. M. J.* **2** 501 (Oct. 14) 1944.

Differing from conventional concepts, Alldredge⁵⁶¹ recommends elevation and use of drains after amputation, not warning specifically about the possibility of acquiring flexion deformities. He does not recommend skin traction except when swelling causes tension of sutures. He urges guillotine amputation at the knee for bad compound septic fracture in the upper part of the tibia and fibula to be followed by secondary supracondylar tendon plastic amputation later. There seems to be some question about these points in our minds, and the reader is referred to the article for confirmation.

Surgical Technic—As regards surgical technic in amputations, many articles have appeared, including two on girdle amputations, one involving an upper and one a lower extremity. Neither of the latter offers anything new in the way of procedure. The one describing the scapulohumeral disarticulation⁵⁶² mentions that it is a much less formidable operation than ordinarily considered. The other⁵⁶³ emphasizes the importance of coincidental transfusions in the interinnominoabdominal amputation and reports 2 cases with successful results.

Kessler⁵⁶⁴ has written another paper on cineplastic operations, recommending that they be reserved for amputations below the elbow rather than above. This complicated surgical procedure is mentioned in many articles, only to be discouraged for the average amputator. It is most satisfactory that this surgeon is still enthusiastic about a procedure which is beyond the ability of most surgeons. The fact that Kessler has an enthusiastic artificial limb maker close at hand, an arrangement not commonly encountered, probably explains his consistent success in a problem in which many have failed. Here is another instance of the necessity of the close coordination of two relatively independent workers in the production of a successful result. He describes nothing new which might simplify the procedure.

The production of a synostosis between the distal ends of the tibia and fibula is recommended by Barber⁵⁶⁵ to produce a better weight-bearing cone-shaped stump for more normal use. He mentions the need of epiphysiodesis of the fibula in growing children to avoid a

561 Alldredge R. H. Management of War Amputations in General Hospital, New York State J. Med. **44** 1763-1770 (Aug. 15) 1944.

562 Wishner, J. G. Scapulo-Humeral Disarticulation. Case Report, Bull. Hosp. Joint Dis. **5** 37-42 (April) 1944.

563 Ghormley, R. K., Henderson, M. S., and Lipscomb, P. R. Interinnomino-Abdominal Amputation for Chondrosarcoma and Extensive Chondroma. Report of Two Cases, Proc. Staff Meet., Mayo Clin. **19** 193-199 (April 19) 1944.

564 Kessler, H. H. Symposium on Reparative Surgery. Cineplastic Amputations. S. Clin. North America **24** 453-466 (April) 1944.

565 Barber, C. G. Amputation of Lower Leg with Induced Synostosis of Distal Ends of Tibia and Fibula. J. Bone & Joint. Surg. **26** 356-362 (April) 1944.

disparity in length of the two bones We, who have had some experience with epiphysiodesis, wonder why he does not include the tibia as well, as a deformity is likely to occur if the growth of one bone is arrested without including that of the other

Electrical desiccation as a mode of treating nerve ends is recommended by Bate⁵⁶⁶ This is a preliminary report, and further conclusions will be hoped for at a later date Along this same line, Boldrey⁵⁶⁷ also makes a preliminary report on the implanting of nerve ends in bone It is encouraging to learn that some surgeons are not satisfied with any of the present varied technics, and it is to be hoped that some time a more certain method will be evolved to avoid painful neuromas after amputation

Surgeon-General Kirk,⁵⁶⁸ long interested in amputations, with McKeever has written an exhaustive treatise on the popular guillotine amputation popular at least from a military point of view The authors decry particularly the dangers of early closed amputations and emphasize the importance of well applied skin traction

For more efficient skin traction, particularly in the tropics, Magrath⁵⁶⁹ writes another military article, recommending the use of strips of Lucite, possibly $\frac{1}{2}$ by 1 inch (1.2 by 2.5 cm), four or more in number, placed on the surface of the skin conveniently near its edge to hold wires or other suitable suture material as a sort of mattress stitch for traction This, we feel is a particularly estimable idea and recommend its employment, even in temperate climates

McKeever,⁵⁷⁰ in another military article, recommends the guillotine operation in the upper as well as in the lower extremity He states that skin traction is essential and advises against any type of skin grafting for the stump end

In an effort to eliminate ill health in long-suffering persons with incurable osteomyelitis, Key⁵⁷¹ advises amputation There are many chronic sufferers with this condition, for which this admittedly radical operation is unquestionably the best solution

566 Bate, J T Method of Treating Nerve Ends in Amputations, *Am J Surg* **64** 373-374 (June) 1944

567 Boldrey, E. Amputation Neuroma in Nerves Implanted in Bone, *Ann Surg* **118** 1052-1057 (Dec) 1943

568 Kirk, N T, and McKeever, F M Guillotine Amputation, *J A M A* **124** 1027-1030 (April 8) 1944

569 Magrath, J L Traction of Soft Tissues New Method Following Amputation, *Mil Surgeon* **94** 373-374 (June) 1944

570 McKeever, F M Upper Extremity Amputations and Prosthesis, *J Bone & Joint Surg* **26** 660-669 (Oct.) 1944

571 Key, J A Amputation for Chronic Osteomyelitis, *J Bone & Joint Surg* **26** 350-355 (April) 1944

Peterson,⁵⁷² in another military article, discusses the management of the whole amputation problem in the army and the plan of handling the thousands of cases in the five amputation centers established in this country in March 1943. Much progress should evolve from this comprehensive coordinated effort to give these soldiers the best results possible. It is to be hoped that the same enthusiasm continues in the veterans' facilities, which will be carrying on this service in peacetime.

For surgeons interested particularly in amputations of hands, Slocum and Pratt⁵⁷³ have written a well illustrated article that deserves careful reading. They differ with Perkins, a Britisher,⁵⁷⁵ as regards amputations at the wrist. The latter argues for a 7 inch (18 cm) stump in the forearm, as an artificial arm cannot be made to fit the distal radio-ulnar articulation satisfactorily.

Perkins discusses the time-honored argument relative to the Syme amputation and, being British, believes that this operation, done so well by the Canadians, should be reserved for men and should be done only by experts. He mentions that one of the chief arguments in favor of the Syme amputation is that the amputee can walk on his stump, but he states that he has yet to see one who when he has his prosthesis off does not hop as do those with a conventional amputation below the knee. He feels that the cineplastic amputations should not be done. They are too complicated for the average surgeon, and if the results are successful the limb is frequently under less control than with a simple stump activated the usual way.

In an article from Russia, Labok and Shenk⁵⁷⁶ argue for early reamputation following the undescribed original procedure, probably of the guillotine variety—in any event, not a closed operation. In as high as 88 per cent of the cases, satisfactory stumps are obtained after reamputation. Two per cent of the unsatisfactory stumps require further surgical treatment, an excellent record.

Barnett and Weinstein⁵⁷⁷ describe what they call a traction cast, better called a plaster cuff, into which is incorporated a Thomas splint sort of loop to which a skin traction arrangement is fastened. The apparatus functions as does a Thomas splint except that the ring is

572 Peterson, L. T. Army Amputation Program, *J Bone & Joint Surg* **26** 635-638 (Oct.) 1944

573 Slocum D. B., and Pratt, D. R. Principles of Amputations of Fingers and Hand, *J Bone & Joint Surg* **26** 535-546 (July) 1944

574 Footnote deleted

575 Perkins, G. Amputations, *Brit J Surg* **31** 377-384 (April) 1944

576 Labok, D. M., and Shenk, N. A. Early Re-Amputation, abstracted *Bull War Med* **5** 21-22 (Sept.) 1944

577 Barnett H. E., and Weinstein L. Use of Traction Cast in Guillotine Amputations, *Bull U S Army M Dept* October 1944 no 81 pp 83-87

replaced by the cone-shaped cuff which serves for countertraction Stockinet glued to the skin with Ace Adherent is employed for traction This article is well illustrated, and the suggestion avoiding the "weight over the end of the bed" difficulty is well taken, in addition to the fact that it is self contained An abbreviated Thomas splint arrangement for this purpose has been described by Pease⁵⁷⁸

An article further decrying the grafting of skin on amputation stumps has been written by Thompson and Alldredge⁵⁷⁹ The danger of primary closure is also discouraged strenuously, particularly in military service As this is another army production, the guillotine amputation is advocated along with skin traction Little mention in any of these articles is made of the treatment of nerve ends which means probably that they are just cut off an inch or so proximally to the muscle edge and allowed to retract without further treatment

More below knee amputations in persons with diabetes are advocated, whenever possible, by Silbert⁵⁸⁰ He stated that in twelve representative New York hospitals there was a mortality of 47 per cent in six hundred and thirty-seven thigh amputations He surprisingly does not advocate skin traction, even though he uses a guillotine amputation He advises against tourniquets, as he reported that he had a number of gangrenous stumps after starting the series In his amputations below the knee, he only had 6 per cent mortality in a series of 82 patients In favor of amputations below the knee, he states that there are fewer painful stumps and that the artificial legs are more often worn

Two military articles on prosthesis have been written by Thomas,⁵⁸¹ in which the following points have been stressed The stump fit, the alignment, the length and the durability of a limb are much more important than the type The success of a limb depends to a considerable extent on the success of the amputation Thomas discusses the mechanics of walking with an artificial leg, in a most understandable way

The use of prostheses for children is discussed by Craft⁵⁸² He approves of the temporary amputations through the knee in children

578 Pease, C N Self-Retaining Traction for Use in Amputations, Bull U S Army M Dept, April 1944, no 75, pp 115-116

579 Thompson, T C, and Alldredge, R H Amputations Surgery and Plastic Repair, J Bone & Joint Surg **26** 639-644 (Oct) 1944

580 Silbert, S Amputation Below Knee for Gangrene in Diabetic Preliminary Report, Am J Digest Dis **11** 394-397 (Dec) 1944

581 Thomas, A Anatomic and Physiologic Considerations in Alignment and Fitting of Amputation Prosthesis for Lower Extremity, J Bone & Joint Surg **26** 645-659 (Oct.) 1944, Permanent Prosthesis, J A M A **124** 1044-1046 (April 8) 1944

for the sake of getting a longer femur, recalling the fact that most of growth occurs in the femur at the distal end. An elbow amputation is not justified, as there is not much growth from the distal end of the humerus. The point of election in the humerus he believes to be the distal end of the middle third. This is a good article on a much neglected subject.

The knee joint of an artificial leg does not satisfy Keith,⁵⁸³ and he has devised a compound-acting articulation, which with his explanation appears to have definite merits, and one wonders why it is not in general use. Its chief object is to give more anteroposterior play in order to avoid excessive pressure at the front of the socket. There must be something wrong about it, as it otherwise would have been adopted by all limb makers.

Suggestions regarding amputations of fingers that have not yet appeared in the textbooks are contributed by Kutler⁵⁸⁴ and, for more extensive injuries to those parts, by McCarroll.⁵⁸⁵ Both articles are directed toward the preserving of as much length as possible by use of adjacent flaps or free splint skin grafts. The procedures are too complicated to abstract adequately, and the reader is referred to the worth while original articles.

Writing about his work in wartime China, Adolph⁵⁸⁶ extols the use of the "delimiting tourniquet" in cases in which a diseased or a hopelessly mangled limb is endangering the life of a person in too poor physical condition to allow immediate conventional amputation. In his experience he has never seen gas gangrene penetrate the tourniquet and for this condition has few opportunities for its use. In cases in which gas gangrene is not too extensive, he feels that conservative treatment—that is, drainage and immobilization—is more successful in saving lives than is amputation.

Cottrell⁵⁸⁷ publishes a report on the use of sclerosing agents combined with drainage for the relief of bursal inflammation. In a series

582 Craft, A. W. J. Prostheses for Children, *Lancet* **1** 639-642 (May 13) 1944

583 Keith, R. Proposed Alteration in Knee Joint of Prosthesis for Below Knee Amputation, *Ann Surg* **120** 803-808 (Nov.) 1944

584 Kutler, W. Method for Repair of Finger Amputation, *Ohio State M. J.* **40** 126 (Feb.) 1944

585 McCarroll, H. R. Immediate Application of Free Full-Thickness Skin Graft for Traumatic Amputation of Finger, *J. Bone & Joint Surg* **26** 489-494 (July) 1944

586 Adolph, P. E. Preoperative Measures Used in War Surgery in China with Special Reference to Delimiting Tourniquet. *Ann Surg* **119** 246-252 (Feb.) 1944

587 Cottrell, J. C. Conservative Treatment of Chronic Bursitis by Injection of Sclerotic Agent—Combined with Drainage. *J. A. M. A.* **124** 81-83 (Jan. 8) 1944

of 27 cases he claims to have obtained twenty-five cures, using various sclerosing agents, such as 5 and 10 per cent sodium morrhuate, 0.5 per cent tincture of iodine, proliferol solution and Sylnasol (a solution of the sodium salts of various of the fatty acids of psyllium seed oil) 5 per cent. The latter he found best for relief of mild types of irritation, without excessive reaction. He employed a small self-retaining drain of his own device. Although this may have the advantage of being an office procedure, one wonders if for the radical removal in the operating room of these bursae that do not respond to conservative treatment, a treatment such as simple pressure with sponge rubber is not preferable.

The use of tantalum wire and foil is urged by Spurling⁵⁸⁸ for all peripheral nerve problems in which it may be suitable. The tolerance of tissue to this inert but, unfortunately, expensive material justifies its use. With increased use, it is to be hoped that its price will become more reasonable.

Davis⁵⁸⁹ describes what seems to be a satisfactory one step fibular substitution of a defective tibia. He thinks that it might be useful in nonunions of the tibia, in which ordinary bone-grafting methods seem inadequate. He warns that the operation is difficult and should not be undertaken lightly. He has had success in all 6 cases in which he has tried this procedure.

Stubbins and White⁵⁹⁰ have made a report on their ten year experience with growth arrests. They have found that the previously reported (1938) yardstick for calculating speed of retardation of $\frac{3}{8}$ inch (0.9 cm) for the distal femoral metaphysial plate and $\frac{1}{4}$ inch (0.6 cm) for the proximal plates of tibia and fibula to be tenable. Their modification of the Phemister operation was found to be adequate for the elimination of the growth disk, and no deformities had resulted. They found that in a few of their earlier cases they had been too enthusiastic and had obtained an overcorrection of the original shortening.

Albee,⁵⁹¹ in his extensive discussion of the evolution of bone transplantation, calls particular attention to the fact that nonunion is usually a biologic and physiologic deficiency and not a mechanical problem.

588. Spurling, R. G. Symposium on War Surgery. Use of Tantalum Wire and Foil in Repair of Peripheral Nerves, *S. Clin. North America* **23** 1491-1504 (Dec.) 1943.

589. Davis, A. G. Fibular Substitution for Tibial Defects, *J. Bone & Joint Surg.* **26** 229-237 (April) 1944.

590. White, J. W. and Stubbins, S. G., Jr. Growth Arrest for Equalizing Leg Lengths, *J. A. M. A.* **126** 1146-1149 (Dec. 30) 1944.

591. Albee, F. H. Evolution of Bone Graft Surgery, *Am. J. Surg.* **63** 421-436 (March) 1944.

Both Steimbrocker⁵⁹² and Gorrel⁵⁹³ once more call attention to the value of the simple office procedure of making injections into the trigger point of pain, particularly in patients with arthritis for which there is no obvious cause. The relief often is only temporary, but if repeated a vicious cycle can be sometimes broken up. This old method seems to merit another trial.

The holding of the proximal end of lacerated unsuturable tendons in approximation by a needle in the soft parts to prevent retraction is advocated as a practical method by Gebhard⁵⁹⁴. The needle projecting through the skin is left in place ten to twelve days and then withdrawn. Gebhard does not mention how many times he has been successful with this simple solution of an often difficult problem, when one hesitates to do a formal tendon transplantation in a fresh wound.

A posterior approach to the middle three fifths of the femur is described by Bosworth⁵⁹⁵ as a worth while procedure. He gives as advantages (1) ease of exposure of area, (2) less bleeding, (3) adequate exposure for two bone plates and (4) no muscle scars or adhesions. He warns against injury to the sciatic nerve.

The use of reduced temperatures for procedures other than amputations is mentioned by Massie⁵⁹⁶ when he calls attention to the "inexcusable menace of applying heat to tissue with reduced and inelastic blood supply". It is going to take a long time for this idea to become disseminated throughout the medical profession, and frequent mention of this "about face" in therapy is desirable. It is important for the general practitioner to realize that ice bags instead of heat should be applied to the pallid cold forearm in a child with a fractured elbow. In this way, the conversion of muscle tissue into a contracting fibrous band may be minimized to some extent.

Friederwitzer⁵⁹⁷ has gone so far as to recommend the employment of ice and ice water as an anesthetic agent in the treatment of local sepsis as well as of dislocated fingers and even elbows. The idea seems

592 Steimbrocker, O. Therapeutic Injections in Painful Musculoskeletal Disorders, with Special Reference to Saline-Procaïne Test, *J A M A* **125** 397-401 (June 10) 1944

593 Gorrel, R. I. Treatment of Skeletal Pain with Procaïne Injections. Analysis of 295 Cases in General Practice, *Am J Surg* **63** 102-104 (Jan) 1944

594 Gebhard, U. E. Repair of Tendons by Transfixion, *Indust Med* **13** 38-39 (Jan) 1944

595 Bosworth, D. M. Posterior Approach to Femur, *J Bone & Joint Surg* **26** 687-690 (Oct) 1944

596 Massie, F. M. Amputation with Refrigeration Anesthesia, *South M J* **37** 1-6 (Jan) 1944

597 Friederwitzer, H. H. Ice as Local Anesthetic, *M Rec* **157** 42-43 (Jan) 1944

a little fantastic, and it is felt that further experimental work should be done on it before it can be accepted

Surgical Instruments—A device for the recovery of the shaft of a screw or similar foreign body in bone whose head has been wrenched off is described by Wolferman,⁵⁹⁸ which on one occasion helped us to get out of a difficult situation. Wolferman describes it as a dowel with a hollow center, which fits over the shaft of the screw and cuts around it sufficiently to permit its being grasped and extracted. It is a useful instrument to have in one's screw kit. He further urges its use in procuring a sample of bone for biopsy, just as a well driller would extract a core of rock for chemical assay.

Only six articles have appeared in 1944 describing new surgical instruments, one of these, from *El dia medico*, not being available to us.

A motor-driven screw-holding screwdriver has been described by Dawson.⁵⁹⁹ This is simply a self-holding screwdriver adapted for use with some motor driven apparatus, such as the Luck saw, with which a low speed is possible. One drawback is that in the use of this the force needed to drive the screw in is not appreciated sufficiently. One of the niceties of bone surgery is the proper use of screws in bone and it is feared that this apparatus tends to lessen the exactness of this point in technic.

A simple miter box arrangement for cutting and facilitating the correct approximation of severed nerve ends has been described by Gross.⁶⁰⁰ It should appeal to surgeons doing much work of this sort, who should welcome an instrument that would make approximation more accurate than the usual freehand procedure. We wonder whether the same idea might not be employed in some way for fashioning freshened bone surfaces in nonunions preparatory to and coincidental with the application of an onlay graft.

Another wire tightener and knot tier has been devised by Harris⁶⁰¹ and should be investigated by those (including us) who are not satisfied with their present procedure. The author suggests a knot rather than a twist, as there is less likelihood of projecting wire ends.

To supplement the equipment for the purpose already devised Peyton, Hall and French⁶⁰² recommended a hook traction instrument for head traction under the zygomatic arch. The chief advantage the

598 Wolferman, S. J. Retriever, J. Bone & Joint Surg **26** 407 (April) 1944

599 Dawson G. R., Jr. Motor Driven Screw-Holder-Screw-Driver, South M. J. **37** 587-588 (Oct) 1944

600 Gross S. W. Device for Accurate Approximation of Peripheral Nerves Bull. U. S. Army M. Dept., April 1944, no. 75, p. 118

601 Harris R. I. Instruments for Tightening Knots in Steel Wire, Lancet **1** 504 (April 15) 1944

authors claim is that desirable hyperextension is obtainable. We wonder whether the visible scarring on the side of the face with this instrument would not tend to discourage its use. The idea is a good one, and in emergencies, when other apparatus is not available, ordinary fishhooks with the barb filed off might be employed.

Apparatus—Nineteen articles that might be classified under this heading have appeared in 1944, only eight, however, are felt to warrant mention in this review.

An apparatus looking like a cookie cutter with a small included plumb bob has been devised by Patrick,⁶⁰² a Britisher, for measuring forearm rotation, a somewhat difficult determination to make as accurately as desired without the help of such an instrument.

Another Britisher has devised a table knife holder for use by a partially paralyzed hand that deserves mention and more publicity in this country. This article by Heal⁶⁰⁴ is well illustrated, and the reader is referred to it for better understanding.

Brayton⁶⁰⁵ has attached a couple of rubber vacuum cups to the back of a hand brush for attachment to a lavatory to help a one-armed man wash his hands. All veterans with an amputated upper extremity should be informed about this worth while aid for persons so handicapped.

Another method, similar to one published several years ago in the American literature using the hydraulic lifting device in the base of an operating table, was described by Lee,⁶⁰⁶ a Britisher, for exerting tibial traction. As a protection against use of too much force in this powerful arrangement, a "tensometer" spring is employed. There must be other purposes to which this easily available force may be advantageously applied.

Jewett⁶⁰⁷ has found many other uses than that originally intended for the conventional walking stirrup used in the Navy. It is particularly applicable as it was made for incorporation in plaster. Among other uses, it can be employed as a *point d'appui* for Crutchfield tor-

602 Peyton, W. T., Hall, H. B., and French, L. A. Hook Traction of the Zygomatic Arch in Cervical Spine Injuries, *Surg., Gynec. & Obst.* 78:222 (Sept.) 1944.

603 Patrick, I. Goniometer for Measurement of Supination and Pronation, *Brit. M. J.* 2:246 (Aug. 19) 1944.

604 Heal, I. C. Table-Knife Holder for Use by Partially Paralyzed Hand, *M. J.* 2:782 (Dec. 18) 1943.

605 Brayton, I. R. Device to Aid Washing of Hand by Paralyzed Arm, *I. A. M. A.* 124:256 (Jan. 22) 1944.

606 Lee, J. E. S. Reduction of Leg Fractures by Hydraulic Traction, *Brit. M. J.* 2:152 (July 29) 1944.

607 Jewett, E. L. Different Uses for Walking Stirrups, *Brit. M. J.* 42:196-200 (Jan.) 1944.

exhaustively into the mechanical or the physiomechanical explanation of the setting. This article should be read by every intern and resident on orthopedic services, as it explains well many of the whys and wherefores of plaster technic.

Plans for a plaster equipment cart have been drawn by Foster,⁶¹⁹ of the United States Army. They should be reviewed by any one contemplating making such a piece of hospital furniture.

An Englishman, Flower,⁶²⁰ recommends once more the use of wire for cutting plaster casts, without any new improvements to make his technic any better than many others of the same type already devised, all of which work if the plaster is not too thick or too thin. What is needed still is an instrument that will cut plasters, regardless of their thickness, without endangering the patient. In our hands the old Stille plaster cutter is still the best.

Carbon as a deodorizing agent in plaster casts is recommended in a new form by Lambert and Stickney.⁶²¹ This has been recommended before, and the article deserves reading by persons who are interested. It does not seem to have any advantage over lactic acid in keeping down odors, but the latter leaves much to be desired. It is to be hoped that some one may devise some sort of container that can be fitted over malodorous casts, with some sort of a neutralizing chemical which can be changed as required.

619 Foster, G. B., Jr. Plaster Cast. Bull. U. S. Army M. Dept., March 1944, no. 74, pp. 120-121.

620 Flower, N. Wire Plaster Cutter, *Lancet* 2:504 (Oct. 14) 1944.

621 Lambert, C. N., and Stickney, D. W. New Deodorizing Plaster Bandage, *J. Bone & Joint Surg.* 26:836-837 (Oct.) 1944.

(To Be Concluded)

REVIEW OF UROLOGIC SURGERY

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KIDNEY

ANOMALIES—Heslin and Milner¹ emphasized the importance of anomalies of the upper part of the urinary tract as the cause of damage to the kidneys. They referred to the work of Gutierrez and others in improving the diagnosis and treatment of these conditions. There are no pathognomonic symptoms of such anomalies of the urinary tract, general abdominal symptoms, sometimes without any symptoms referable to the urinary tract, often are present. The diagnosis depends on keeping the possibility of these anomalies in mind and on the use of intravenous urography in cases of vague pain in the abdomen and back and recurrent infection of the urinary tract. If intravenous urography is unsatisfactory, it must be supplemented by retrograde pyelography. Retrograde pyelography is also necessary to secure information to indicate the treatment to be used and to guide the surgeon. Removal of the factor causing the obstruction and resulting damage to the kidney may require only a simple procedure or a complicated plastic operation. In such operations, careful splinting of the ureter, the use of fine sutures, careful coaptation of the edges and nephrostomy drainage for varying periods are of importance in securing a successful result. The authors

This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth in this article are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

1 Heslin J E., and Milner W A. Anomalies of the Upper Urinary Tract, New York State J Med 45 388-390 (Feb 15) 1945

have also found that the administration of the sulfonamide drugs before and after operation has improved results

Gutierrez² pointed out that congenital malformations may give rise to abdominal symptoms and that the presence of the anomaly itself may be unsuspected unless a urologic examination is made. Such malformations may, however, cause symptoms referable to the urinary tract or be associated with other pathologic conditions which cause such symptoms. When excretory urography shows the presence of such an anomaly, a complete urologic examination should be made. This should include bilateral retrograde pyelograms. If such studies show total absence of function of the involved kidney, nephrectomy is indicated, but in selected cases conservative "orthopedic" operation for correction of the malformation can be done with good results. The most common congenital anomalies of the kidney are congenital hydronephrosis, double kidney, horseshoe kidney, large solitary cyst of the kidney and polycystic kidney.

The commonest causes of congenital hydronephrosis are stenosis or stricture at the ureteropelvic junction with or without valve or constricted fibrous ring, aberrant polar blood vessels, fibrous bands of adhesions with kinking of the ureter, high insertion of the ureter and malposition of the kidney. The details of the plastic procedure depend on the condition present in each case, but in all the author's cases of this type complete nephrolysis and ureterolysis were done. In some cases nephrostomy was performed and drainage was continued for from three to four or six weeks. Nephropexy was also done in all cases to maintain the kidney and ureter in good position. In cases of double kidney, the best results are obtained with heminephrectomy and removal of the corresponding ureter. The operation may be completed by nephropexy of the half of the kidney left in situ.

Horseshoe kidney is one of the most important congenital malformations of the kidney. Cases of horseshoe kidney may be classified in five groups: (1) cases in which there are no painful symptoms (silent type), (2) cases in which there are indefinite abdominal pain, urinary symptoms and gastrointestinal symptoms, (3) cases in which there is a gross pathologic lesion in half the fused organ, (4) cases in which there is a gross pathologic lesion in both renal pelves, and (5) cases in which the anomaly is associated with other anomalies, such as duplication of one or both pelves and ureters. For the reconstruction of the fused organ in cases in which there are typical symptoms of horseshoe kidney (group 2), symphysiotomy, or division of the renal isthmus by an extraperitoneal route is done. This is followed by nephrolysis,

² Gutierrez, R. Orthopedic Surgery for Reconstruction of Congenital Malformations of the Kidney, *Surgery* 17: 122-134 (Jan) 1945

ureterolysis and right nephropexy. In cases of group 3—that is, cases in which there is a gross pathologic lesion in one of the halves—various procedures may be used. Pelviureteral anastomosis may be necessary for correction of hydronephrosis. In some cases of advanced nephrolithiasis, tuberculosis or tumor of half of the horseshoe kidney, heminephrectomy is indicated.

In cases of large solitary cysts of the kidney, a conservative operation is often possible. One may perform either a total resection of the cyst alone or a partial nephrectomy so designed as to reconstruct the organ. In cases of polycystic kidney, nephrectomy may be indicated if there is sufficient function in the kidney on the opposite side. Conservative operation such as pyelolithotomy, nephrolithotomy, multiple aspiration of cysts and renal decapsulation may also be done in some instances.

Tumors—Hanley³ stated that bilateral renal carcinoma is extremely rare and that only about 9 cases have been recorded in the literature. Most of the authors present their cases as examples of two primary growths, and the evidence that was presented to prove that one of the tumors was not metastatic varied in individual cases. In all but 1 of the recorded cases the tumors were “hypernephroid” carcinomas or Grawitz tumors, the exception was a case of bilateral papillary carcinoma of the renal pelves. The patient was a man, aged 73 years who complained of hematuria, loss of weight and a mass in his right loin. Intravenous urography and retrograde pyelography showed some abnormality of both renal pelves. He lost weight rapidly and died ten months after the onset of symptoms. At autopsy, bilateral renal neoplasms were found. Several small nodules on the parietal pleura which subsequently proved to be secondary hypernephroma deposits, were the only evidence of generalized metastasis.

Bothe⁴ discussed the relationship of epithelial buds to carcinoma of the pelvis of the kidney, ureter and bladder. His original work included a routine study of the ureters at 54 consecutive autopsies and a study of 12 surgical specimens. The postmortem material revealed epithelial cell nests in 38 cases. These observations are in favor of Brunn's ideas concerning development of cell nests. This study indicates that these cell nests may be the result of developmental inclusions or that they may be secondary to mucous membrane crypts. That all these pathologic changes may be due to underlying inflammation is readily possible. Many of the patients from whom the necropsy material

3 Hanley H. G. Bilateral Renal Carcinoma. *Brit. J. Surg.* **32**: 399-402 (Jan.) 1945.

4 Bothe A. E. The Relationship of Epithelial Buds to Carcinoma of Pelvis of the Kidney, Ureter and Bladder. *J. Urol.* **53**: 451-458 (March) 1945.

was obtained died of carcinoma of other tissues. However, in no case did the author find any neoplastic change associated with the buds or cell nests.

Study of the surgical specimens disclosed 4 papillary carcinomas of the renal pelvis, 7 of the ureter and 1 of the bladder. The tissues distant and adjacent to the primary carcinoma were studied. They did not appear malignant or pathologic. This study revealed subcutaneous hyperemia with mild or associated round cell infiltration. In some areas this condition was associated with digitation of the epithelial cells into the subepithelial supporting tissue.

Bothe's study and the studies of other investigators have proved that epithelial buds are not uncommon in the renal pelvis, ureters and bladder. The tendency of multiplicity of tumors of the bladder and ureters is accepted. The accumulated evidence in favor of carcinogens has become exceedingly important, although most of the carcinogens are still in the experimental stage.

Bothe's study of the postmortem material and the surgical specimens has shown that epithelial buds are present with and without associated carcinoma of the renal pelvis, ureters and bladder. Although these buds can be identified as transitional cell types, they are not maturely developed. They are incompletely differentiated. Since a systemic chemical basis for carcinoma is not without stimulating evidence, it seems that the immature buds may be the tissue susceptible to activation.

If this hypothesis be true (granted it is not proved) how may these cell buds be rendered inactive or unsusceptible? An approach may be by the roentgen rays. In support of this possibility, Bothe reported 4 cases. The patients were first seen in 1936. They had low grade, small multiple papillomas of the bladder. Two patients were treated by roentgen therapy. This therapy established no appreciable change in the gross appearance of the tumors. They were subsequently destroyed by transurethral desiccation. The follow-up study of these patients has never revealed any evidence of recurrence. The other 2 patients, with a similar type of vesical papilloma, were treated by transurethral desiccation alone. These patients up to the present time have had repeated recurrences. If the recurrences were due to susceptible epithelium or susceptible epithelial nests, it may be assumed on hypothetical grounds that the roentgen therapy established changes in this epithelium which rendered the tissue less susceptible to carcinogenic irritation.

Lubash⁵ reported 33 cases of renal tumor. Hypernephroma, which was the commonest type, occurred in 22 cases (65 per cent). Ten of

⁵ Lubash S. Renal Tumors Simulating Gastrointestinal Disease, *New York State J Med* 45:45-51 (Jan 1) 1945.

the patients had gastrointestinal symptoms only, while 12 had hematuria as the first symptom. There were 3 cases of renal carcinoma. Gastrointestinal symptoms were present in all these cases. Operation was done in 1 of these cases because of suspected ovarian cyst or pedunculated fibroid, in the other 2 cases it was done for a suspected malignant lesion of the intestinal tract. The renal carcinoma was found at operation in each case. There was 1 case of lipoma of the kidney and 1 of a tumor of unknown type. Gastrointestinal symptoms were present in both of these cases. In the latter case the tumor was retroperitoneal. The tumor sac was marsupialized and deep roentgen therapy was employed. This resulted in pronounced regression of the tumor and relieved the symptoms. There were 6 cases of tumor of the renal pelvis, in all these cases the symptoms were urologic. The most frequent symptom was hematuria. There were no symptoms referable to the intestinal tract. Four of these tumors were carcinomas and two were benign fibroepitheliomas. Nephrectomy was done in 5 cases, 1 patient died in uremic coma before operation was attempted. This type of tumor can be diagnosed early only if pyelography is done during a period when there is no bleeding and repeated if a filling defect, however small, is found. If such a defect is found on the second examination, operation should be done promptly.

incident to prolonged inactivity, which might otherwise aid in the passage of small nuclei of crystals and sediment

Unless infection occurs, renal calculi which form in bedridden patients are likely to remain unrecognized until activity is again resumed. For this reason, save when the period of inactivity is relatively short, calculi are usually large and call for surgical treatment.

Leadbetter and Engster have encountered 14 patients with renal and ureteral colic or suspected renal calculi who gave no history of previous passage of calculi, hematuria or renal colic. It is assumed that the development of gravel or calculi in these patients took place during hospitalization.

Hospitalization was required because of injuries or wounds in 12 of the 14 cases. Four patients had flesh wounds only, but all were severely wounded. Eight patients had, in addition to extensive wounds of the soft tissues, injuries of bones of varying severity.

The time between injury and onset of urinary symptoms varied from eight to one hundred and sixty-four days, the average was 70.8 days.

Five patients had bilateral ureteral colic during the period of observation.

Roentgenographic studies were made in all but 3 cases. In only 3 instances were definite calcified opacities demonstrated. In 2 other cases, a questionable shadow was noted in the region of the lower part of the ureter.

Obstruction which could be dignified by the term "calculus" actually was demonstrated in only 4 of the 14 cases. It will be noted that the obstructing masses usually were loose aggregations of crystals or masses of amorphous material.

Adequate amounts of fluid during the whole period of immobilization are essential for prevention of stones, but the critical period shortly after injury requires special attention. A fluid intake of 3 to 4 liters is a minimal requirement. Furthermore, it is desirable to administer fluids as nearly as possible in an around the clock fashion rather than to give large amounts of fluid during the day and none at night. Fruit juices, which are frequently given, tend to produce an alkaline urine, which is undesirable.

Another and equally important detail undoubtedly is the frequent turning of patients from side to side and from back to front. Patients in body casts or with injuries of the spinal cord should be turned every two or three hours. If possible, the head and upper portion of the body should be elevated for periods each day to assist in emptying the renal pelves. Leadbetter and Engster have followed such a regimen in the treatment of injury of the spinal cord and have not as yet been called on to treat any complications of the upper part of the urinary tract in 60 to 70 patients.

Since many patients excrete an alkaline urine, the question of acidification of urine must be considered. It is believed that acidifying drugs should not be given early after injury, since they tend to increase the mobilization of calcium and phosphorus from bones. Instead, large amounts of fluid should be given in order to maintain as dilute a urine as possible.

Later, in certain cases, soft calculi may be dissolved either by maintaining an acid urine by oral administration of acidifying drugs or by the use of Solution G (a solution of citric acid, magnesium oxide and sodium carbonate of p_H 4) within the renal pelves. Since, in general, the calculi have a loose structure, they should respond to such methods of treatment in many instances.

Shorr⁷ called attention to the usefulness of estrogens and aluminum hydroxide gels of the Amphojel type as adjuvant measures in the management of nephrolithiasis in which the stone is composed of calcium phosphate or carbonate, magnesium phosphate, magnesium ammonium phosphate or calcium magnesium ammonium phosphate. Estrogens, by increasing urinary excretion of citrate, reduce the concentration of the calcium ions participating in the precipitation of calcium phosphate. They are replaced by a weakly ionized, soluble calcium citrate complex. Amphojel, by diverting excretion of phosphate from the urinary to the intestinal tract, reduces the number of phosphate ions participating in the same reaction. A combination of these two measures should provide considerable protection against precipitation of calcium phosphate, even at alkaline ranges of urinary p_H , and in the acid range should lead to appreciable undersaturation with respect to calcium and phosphate ions.

The details have been given for the most advantageous utilization of estrogens and Amphojel in the management of renal stones, however, too brief a clinical trial has been made to permit conclusions as to the actual effectiveness of these measures in the prevention of recurrences or of further growth of the calculi.

Hydronephrosis—Gibson⁸ reviewed hydronephrosis due to obstruction at the ureteropelvic junction and described the three general types of obstruction and the principal methods of pyeloplasty in current use.

Experience with pyeloplastic repair suggests the possibility of eliminating the elaborate plastic operations and the delicate suturing they entail in favor of the simpler method. The value of pyeloureteral splinting and intubation in selected cases was reemphasized as an insurance against failure. It is even possible that these procedures may super-

7 Shorr, E. The Possible Usefulness of Estrogens and Aluminum Hydroxide Gels in the Management of Renal Stone, *J Urol* **53** 507-520 (April) 1945

8 Gibson, T. E. Hydronephrosis, *Surg, Gynec & Obst* **80** 485-496, (May) 1945

sede to a large extent plastic operations on the ureter and ureteropelvic junction. At the present time, pyeloplasty and ureteral splinting or intubation are effective when used conjointly. Future experience will determine the relative roles as well as the comparative merits of the various methods of pyeloplasty.

Cystic Disease—Lowsley and Curtis⁹ stated that the term "solitary" renal cyst is erroneous and should be replaced by the term "simple" renal cyst.

Satisfactory results will be obtained in the great majority of cases of simple renal cyst by resection of the free portion of the wall of the cyst, subsequent phenolization of the base of the cyst and closure of the resultant defect with a fat pad and chromic ribbon gut. Nephrectomy is indicated in only a small percentage of cases.

A malignant lesion should be strongly suspected in all cases in which renal cysts contain hemorrhagic material, and unless a malignant lesion can be definitely ruled out nephrectomy should be done, as approximately 25 per cent of hemorrhagic cysts have been found to be malignant.

Polycystic renal disease is a congenital, probably always bilateral, and progressive pathologic entity. Operation for this condition is limited to the complications arising from it. Much can be done in prolonging and making comfortable the lives of patients with polycystic disease by the employment of a judicious medical regimen. Nephrectomy should be done only as a life-saving measure in cases of polycystic kidney.

Renal operation is indicated for the great majority of patients with echinococcus cysts of the kidney. At operation, great care must be exercised in preventing spillage of the cystic contents, since severe anaphylaxis, which is often fatal, may result or parasites may be implanted in the contaminated tissues.

Braasch,¹⁰ in discussing cystic disease of the kidney, called attention to the desirability of using the term "simple cyst" rather than "solitary cyst." There may be one large simple cyst present in the kidney, but other smaller cysts usually accompany it and often they occur in both kidneys. The term "solitary cyst," therefore, is a misnomer in most cases. Multiple large simple cysts are frequently found in the kidney. These cysts may cause urographic deformity which is suggestive of polycystic disease, and they have also been so regarded on surgical exploration. In reviewing the surgical records of patients with simple renal cysts observed during the last five years at Mayo Clinic Braasch

⁹ Lowsley, O. S. and Curtis, M. S. The Surgical Aspects of Cystic Disease of the Kidney. *J. A. M. A.* **127** 1112-1119 (April 28) 1945.

¹⁰ Braasch, W. F. in discussion on Lowsley and Curtis,⁹ p. 1119.

said that in 20 per cent of the cases multiple renal cysts of appreciable size were found at operation. In the early days of urography, it was thought that the presence of simple renal cysts could always be recognized by the crescentic outline and the other well known deformities of the calices and renal pelves that usually accompany renal cysts.

Surgical exploration is necessary in practically every case, since the possibility of renal neoplasm must be excluded. Aspiration of renal cysts is not a good surgical procedure, and it often is unsatisfactory. Surgical exploration is preferable except in a few cases in which the patients are elderly or are gravely ill. In regard to polycystic kidney, although the diagnosis is usually made without too great difficulty on the basis of the clinical and urographic data, the lesion is often overlooked. Not infrequently only one kidney is enlarged on examination and the other cannot be felt. Urography may show a deformity in the enlarged kidney which is suggestive of polycystic disease, but the other one may have little or no deformity and its function may be normal. It would be easy to infer from this that one is dealing with a unilateral renal condition, possibly neoplasm or one or more simple cysts.

Many complications may occur with renal polycystic disease. The Rovsing operation for polycystic disease would seem theoretically to be a logical procedure. Every now and then some one reports 2 or 3 cases in which this method of treatment has been employed. However, several of the patients on whom this operation was performed did not have very satisfactory results. In 2 cases postoperative complications occurred and necessitated nephrectomy. The patients observed in the other cases did not seem to be greatly benefited by the operation.

Livermore,¹¹ in discussing cystic disease of the kidney, stated that solitary cysts of the kidney usually occur at the lower or the upper pole. He observed a case in which the cyst covered the whole anterior surface of the kidney. It was firmly attached to the kidney. He dissected as much of the sac as possible and then treated the remainder with an escharotic solution. Livermore has always been of the opinion that polycystic kidneys should not be operated on unless some definite reason calls for the operation, such as repeated hemorrhage, infection or stone. He performed operations in a number of these cases for hemorrhage or infection because the hemorrhage had been so severe that the patients were anemic. In such cases, the patient is helped by the breaking up of as many cysts as possible and the ligation of all bleeding points.

Trauma—Sargent,¹² in discussing injuries of the kidney, stated that every patient who has received serious body injury should be made

11 Livermore, G. R., in discussion on Lowsley and Curtis,⁹ p. 1119.

to void or be catheterized as one of the first steps in the examination. Until this procedure becomes routine, recognition of injuries of the urinary tract will continue to be delayed fateful hours or even days, and the mortality will continue to be appalling.

Gross hematuria in cases of accident demands prompt investigation. Many times it proves to be of no special consequence but often it bespeaks injury of the first magnitude.

Excretory urography can be useful as a preliminary procedure in cases in which an injury of a kidney is suspected. Retrograde pyelography, however, gives consistent dependable help in determining the true extent of injury.

Most injuries of the kidney should be left alone. With the renal pelvis reasonably intact, even though substantial fracture of the parenchyma has occurred, one does not expect to meet alarming hemorrhage, and with persistent indifference on the surgeon's part one is likely to see the patient soon recovered. If, on the other hand, the contour of the renal pelvis is altered beyond recognition, there can be no hope whatever for that kidney and but little for the patient unless a nephrectomy is done.

Renal Glycosuria—Brush¹³ stated that renal glycosuria is a complication of advancing age and is found particularly in persons who have had some type of obstructive uropathy.

Glycosuria may be constant or intermittent, is usually mild and is never associated with hyperglycemia. Diagnosis is made from the family history, the finding of glucose in the urine and strictly normal blood sugar and glucose tolerance tests. Routine reexamination is essential to rule out diabetes mellitus. Treatment includes a normal balanced diet, with slight restriction of carbohydrates. Diabetic management of this entity is dangerous to health and life. Permanently diminished renal function due to prolonged obstructive uropathy may cause a persistently lowered renal threshold. Reduced ability of the tubules to reabsorb is accompanied with a higher glucose clearance and establishes the relationship between urinary stasis and renal glycosuria.

URETERS

Anomalies—Bacon¹⁴ reported 3 cases of ectopic termination of supernumerary ureters. In each case, the lesion was diagnosed before

12 Sargent, J. C. Injuries of the Kidney, *J Urol* **53** 381-386 (Feb.) 1945.

13 Brush, F. H. Renal Glycosuria. President's Address, *J Urol* **53** 362-364 (Feb.) 1945.

14 Bacon, S. K. Pathologic Lesions Associated with Ectopic Termination of Supernumerary Ureters. Report of Three Cases, *J Urol* **53** 402-407 (Feb.) 1945.

urologic operation was performed. Aberrant ureteral endings predominate in cases in which the patients are female. In the case of women the diagnosis is suggested by the presence of urinary incontinence which has been present since birth and associated with normal micturition. Ureteral catheterization and pyeloureterography of the ectopic conduit are the most conclusive diagnostic procedures. Heminephrectomy is the method of choice to effect a cure. Nephrectomy is indicated when the vascular system is unfavorable for partial resection of renal substance when the ectopic ureter drains a normal kidney and when the caudal segment or its ureter is diseased or remarkably anomalous.

Calculi—Councill¹⁵ reported 504 cases of ureteral calculi of the type which could be removed from the ureter by means of his ureteral dilator and stone extractor.

In this series, three hundred and sixty-four stones were successfully removed from all parts of the ureteral tract. There were fifty-seven in the upper, eighty-six in the middle and three hundred and sixty-one in the lower third of the ureter. Of this number twenty-six were removed from the upper, sixty-seven from the middle and two hundred and seventy-one from the lower third. Councill was unable to pass the extractor beyond the stone in 12.9 per cent of the cases, but in 84.8 per cent of those cases in which he was able to pass it beyond the stone it was possible to remove the stone. After manipulation, 9.2 per cent of the stones were passed spontaneously in one to fifteen days, and 6 per cent never were passed.

Councill said that all ureteral stones should be given a chance to pass spontaneously, it is his custom to wait ten to thirty days before admitting the patients to the hospital for extraction of the stone. During the interim, the ureter should be dilated from time to time and Trasentin (diphenylacetyl diethylaminoethanol hydrochloride) and Depropanex should be administered for their antispasmodic effect. Codeine and acetylsalicylic acid should be given for pain, and one of the sulfonamide drugs should be administered if infection is present. Fluids should be forced at all times.

The period of hospitalization depends on the severity of the symptoms. Councill found that the preoperative treatment required one to thirty days, with an average of ten days, while the postoperative treatment required one to six, with an average of three days.

Complications occurred in 2 per cent of the cases. Reflex anuria occurred in 1 case and lasted for forty-eight hours, phlebitis occurred

15 Councill W. A. The Treatment of Ureteral Calculi. A Report of Five Hundred and Four Cases in Which the Councill Stone Extractor and Dilator Was Used, *J Urol* 53: 534-538 (April) 1945.

to 2 cases, infection of the blood stream occurred in 2 cases, and rupture of the ureter occurred in 3 cases. In 1 of the cases of infection of the blood stream the patient recovered, in the other case the patient died of a cerebral abscess. In 2 of the cases in which there was a rupture of the ureter, operation saved the patients, in the third case, a patient died of respiratory failure following spinal anesthesia.

The preoperative treatment consists in the use of ureteral dilation and retrograde and intravenous pyelograms have been made. It is necessary to know the site of the stone and the size of the tract above and below the stone. The site may be determined not only by pyelography but more successfully by the teleprobe. This is a hypersensitive electric instrument which by variations in amplitude of sound registers the presence of a stone in the ureter on contact. The sound which is obtained depends on the fixation, size and density of the stone. It is well to remember that the size of the stone must reasonably approximate the size of the tract through which it is to be removed. If a stone should be extracted until the tract below has been thoroughly dilated. The size of the tract below the stone, not the size of the stone, is the index for extraction.

The patient is prepared in the usual manner for cystoscopy. Pentothal sodium, gas or ether or spinal anesthesia is employed. Councilman said that spinal anesthesia is the best choice because of the ureteral relaxation that it affords. Pentothal sodium, gas and ether do not give ureteral relaxation, and spasm of the ureter may be encountered during the act of extraction. This is not the rule with spinal anesthesia. For direct observation cystoscopy only should be used, and Councilman's choice is a 24 F. McCarthy Panendoscope. The extractor is passed through the McCarthy cystoscope, and the filiform is inserted into the ureter. The convexity of the wire basket should lie in a posterior lateral position. The basket should never be rotated inside the ureter. This can be done with the basket between the ureteral orifice and the beak of the panendoscope, under direct vision. Rotation is always to the right to avoid unscrewing of the filiform. As the instrument ascends the ureter, it should always be dilated slowly, never quickly. After the basket passes the stone, it should be opened and then withdrawn until the stone becomes engaged. The ureter above the stone is always dilated, which makes it possible to open and withdraw the basket with perfect safety while engaging the stone. After the stone is engaged, the basket is opened and closed several times to insure a snug fit. The extractor is withdrawn with the basket closed, and it is kept under vision as it emerges from the ureter. If the stone is not seen in the basket, the operation should be repeated but never more than three or four times. If one stops the operation at this point, the stone will

usually pass in twenty-four to forty-eight hours. Occasionally during the extraction spasm occurs or the stone becomes partially engaged and prevents easy withdrawal. If this happens, the ureter is dilated gradually and then the extractor is withdrawn. Force should never be used and one should not hesitate to leave the extractor in place for twenty-four hours, after which it can be easily withdrawn, with the stone enmeshed in the basket. After the stone has been removed from the ureter, a no. 9 ureteral catheter should be passed immediately to the renal pelvis and left in place.

The ureteral catheter is left in place for twenty-four to seventy-two hours, depending on trauma and color of the urine. The renal pelvis is irrigated every six hours with 0.5 per cent solution of merbromin.

The higher the stone is in the ureter, the greater the possibility for trauma. For this reason, Councill stated the belief that stones should be removed only from the lower third of the ureter. The secret of the whole procedure depends on gentleness. One should dilate not quickly but slowly, force should never be used, nor should one exert more than a reasonable pull during the extraction. All stones should bear a like ratio to the tract through which they are to be removed. Success depends on four factors: site of the stone, size of the stone, size of the tract above and below the stone and ability to pass the extractor beyond the stone.

Ureterostomy—Huggins and Scott¹⁶ considered cutaneous ureterostomy. A new method of unilateral ureterostomy with ligation of the opposite ureter was described, with its proposed advantages. The operation entails little risk. There were no operative deaths in the series of 9 cases in which this procedure was employed. Seven of the patients subsequently underwent total cystectomy.

A Foley balloon catheter is inserted through the ureter into the renal pelvis for collection of urine. This is free of leaks and does away with the devices necessary when a plain catheter is used. Ligation of the ureter of a normal kidney is not accompanied with renal colic, and the patients do not complain of pain. There were no signs of an acute inflammation of the kidney following ureteral ligation in this series of cases, although some of the patients had grossly infected urine, purulent in nature. After this series of cases was observed, however, the authors observed another case, in which renal infection developed although the ureteral urine was sterile. The kidney had to be removed. The absence of febrile response may be associated with chronic infection in which renal immunity was established.

16 Huggins, C, and Scott, W. W. Cutaneous Ureterostomy with Contralateral Ureteral Ligation, *J Urol* **53** 325-338 (Feb.) 1945

Mathe ¹⁷ stated that ureterocutaneous anastomosis is especially indicated in cases in which the bladder has been damaged irreparably by incurable disease and obstruction and infection of kidneys and ureters have resulted. The operation is simple, rapid and benign and is particularly suitable for debilitated patients.

Patients who tolerate retention catheters appear to have fewer complications. Careful selection of patients, frequent reexamination and adequate after-care are necessary for a successful outcome. Under these conditions, the urinary function is satisfactory, infection is controlled and life is prolonged.

Late results in 2 previously reported cases were given. In the first case the patient is free of tuberculosis sixteen years after ureterocutaneous anastomosis was performed for intolerable tuberculous cystitis which persisted after nephrectomy. He leads a satisfactory life with an indwelling catheter and works hard. The second patient, who is intolerant to an indwelling ureteral catheter, has had several septic episodes, which have responded promptly to treatment. She is now in good health and at work, twenty-three years after ureterostomy was performed.

Denervation—Castro ¹⁸ carried out experiments on 22 dogs to discover what dynamic and morphologic changes occur in the ureter after sympathectomy and after crushing of the ureter. His results, which were given in detail, led him to take sharp issue with the classic writers (especially Caporale, Blatt and Marion) who claimed that destruction of the adventitia of a cylindric segment of the ureter 1 cm. in extent results inevitably in a dilatation of the excretory urinary passages above the segment. He demonstrated that such dilatation, when it does occur after sympathectomy or after crushing with forceps, cannot be attributed to the simple extirpation of the adventitia or to crushing, since ureteritis and periureteritis are constantly encountered in these cases. He also observed that, notwithstanding the presence of ureteritis and periureteritis in ureters that had been denervated or crushed with forceps, the ureter failed to appear dilated above the point of trauma in 66 per cent of cases, even when such trauma was gross and was repeated. One of the characteristics of the periureteritis was that it occurred less than ten days after operation.

Dilatation below the point of such intervention or crushing has not been recorded by any author, yet this phenomenon was observed by

17 Mathe, C. P. Ureterocutaneous Anastomosis. Late Results in Two Previously Reported Cases, *J. Urol.* **53** 397-401 (Feb.) 1945.

18 Perez Castro, E. Dynamic and Morphologic Changes in the Ureter Following Periureteral Sympathectomy, *Arch. españ. de urol.* **1** 1 and 36-65 (July) 1944.

Castro with extreme frequency and was interpreted by him as an antiperistaltic reaction due to the irritative character of the ureteral intervention

The ureter which is an organ of complex motility, possesses compensatory mechanisms, which enable it when it is caught in a suture or crushed to overcome the difficult conditions thus created and to remain permeable. The destruction of the suture in transverse sections of the ureter should not be attributed to interruption of the adventitia, as a number of authors hold, but rather to its imperfection, which allows urine to escape and to infiltrate the periureteral tissues, thus causing in them an intense reaction

Castro's experiments, therefore, fully justify a more optimistic view than that of Caporale, Blatt and Marion, who condemned offhand any attempt at a suture in transverse sections of the ureter. His demonstration that the inclusion of a ureter in a suture has no importance and does not by any means signify the loss of a kidney has great practical interest for the surgeons who in certain operations (hysterectomy) dread the danger of accidentally including a ureter in a suture through failure to recognize it

Ureteral Syndromes—LeDuc¹⁰ stated that the presence of ureteral disorders in males is commoner than is realized and that they should be thought of in any case in which a patient complains of a combination of renal or ureteral pain in any of its referred forms and of disturbances of micturition, particularly frequency and urgency, dependent on such pain coming on as the bladder fills. Adults with enuresis should be studied for evidence of ureteral disease if any of these symptoms are present. Testicular pain without evidence of local organic disease is often due to ureteral disease. Patients with chronic pyuria often have ureteral obstruction, on which the continuance of infection probably depends. The pain syndromes involving the ureter and the site of the referred pain may be likened to mild ureteral colic and probably depend on focal irritation of the ureteral wall or of the periureteral nerve fibers and ganglions

Patients with ureteral syndromes are not suited for military service except in occupations which do not require strenuous exertion

Treatment of ureteral syndromes requires patience and persistence. It should consist in periodic ureteral dilations, use of antispasmodics and eradication of local or focal infection

Clinical studies should be carried out to determine the ultimate fate of patients with this syndrome, particularly in regard to the develop-

19 LeDuc, I. E. Ureteral Syndromes in the Male, *J Urol* **53** 295-318 (Feb) 1945

ment of infection, and, in cases of urinary infection, to determine whether such infection may produce structural ureteral change

BLADDER

Tumors—Balfour²⁰ stated that endometrioma of the urinary bladder was first described as an entity in 1931. Forty-six cases have been recorded in the literature since that time. Usually there are other endometrial implants, and in 42 of the 46 cases reported pelvic operations had been performed or there was an associated pelvic disease.

The symptoms of the endometrioma may be hematuria, fulness of the bladder, pain, dysuria and urinary frequency and urgency. Symptoms may be definitely cyclic, and their appearance may correspond to menstruation. If there is a sizable mass in the vesical wall, symptoms attributable to this mass will be almost constant. As in endometriosis elsewhere, the symptoms will subside with pregnancy and with the menopause. Cystoscopic examination will reveal a mass or a typical but changing picture of the ulcerated or submucosal lesion. Biopsy of this lesion may show the endometrial tissue.

Successful excision has been carried out in 9 of 10 young women whose cases were reported in the literature. In older women, treatment may consist in induction of the menopause by irradiation or operation.

In the past twelve months at Mayo Clinic, 5 cases of endometrioma of the bladder have been encountered and treatment given. All 5 patients had undergone pelvic operations previously or had associated pelvic disease, and all the patients had some urinary symptoms. The urinary symptoms were severe enough in 3 cases to require cystoscopic examination. The cystoscopic examination aided the diagnosis in 2 of these cases, and in the third the endometrioma was confused with inflammation and carcinoma. It is well to remember that substitutional hormonal therapy is not indicated after menopause has been induced for this condition.

Cook,²¹ in discussing endometrioma of the urinary bladder, stated that this condition is not common but undoubtedly occurs oftener than is usually believed. Almost any condition involving the bladder may cause symptoms which are similar in character. These are dysuria, urinary frequency and urgency, a sense of pressure in the lower part of the abdomen and occasionally hematuria. Consequently, further efforts must be made to obtain information which suggests the presence of endometriosis of the bladder. As Balfour pointed out, the cyclic character of the basic symptoms should indicate the presence of this

20 Balfour, D. C., Jr. Endometrioma of the Urinary Bladder. Report of Five Cases, Proc. Staff Meet., Mayo Clin. **20**: 129-131 (May 2) 1945.

21 Cook, E. N., in discussion on Balfour,²⁰ p. 132.

condition. However, the symptoms will not always bear a relationship to the menstrual period but frequently will. Even in cases in which symptoms are present almost continuously, they are usually severer during the menses. Another point of interest is the age of the patients. The condition has been observed in a woman of 18 years and also in one of 46 years. However, the average age of the patients in the reported cases is 39 years, and the majority of the patients are between 35 and 40 years. If any of the patients who are suspected of having endometriosis of the bladder have been pregnant, it is well to inquire concerning their symptoms during this period. In most instances, the lesions will disappear at this time and the patient will have none of the usual symptoms. After delivery, the symptoms return with the menstrual cycle.

The cystoscopic picture in endometriosis of the bladder is of interest. At times the lesion has suggested only cystitis and has been incorrectly diagnosed as such. The cystoscopic picture in the 5 cases reported by Balfour has not had any definite characteristics. A gross lesion which appears to be submucosal and at times ulcerated has been noted. The usual site is in the base of the bladder, but it also has been found in the dome and on the lateral walls. The confusion of this condition with carcinoma is frequent, and many times biopsy and repeated cystoscopic examination will be required, together with a careful evaluation of the history, in order to arrive at the correct diagnosis. Cystoscopic examination at intervals is valuable because of the possibility that variations in the lesion and its relation to the menstrual cycle may be noted. In the intermenstrual period, it will appear as a much more benign lesion than it does during the menses. The cystoscopic picture also will vary if the patient has had roentgen therapy or is pregnant or if hormonal substitution therapy has been used. Biopsy must not be considered diagnostic unless the conditions observed are positive, for it has been possible to demonstrate endometriosis by biopsy in only about a third of the cases. This is probably due to the fact that when the specimen is removed for diagnosis only the superficial tissue is removed and the deeper structure which contains the endometrial glands is not disturbed.

Ferris²² stated that in order to determine the treatment of choice for endometrioma of the urinary bladder the age and general condition of the patient, the severity of symptoms and the associated pelvic lesions must be considered. If the endometrioma involves only the bladder, local excision of the endometrioma should be considered first for those women who are not near the menopause. For women who are near the menopause, roentgen therapy directed at the ovaries should

be considered. If, however, the symptoms are minimal, the patient can await the menopause for relief.

In most cases, however, pathologic changes are present in the reproductive organs in addition to the endometrioma of the bladder. For the younger women of this group, local excision of all the abnormally placed endometrial tissue and the diseased pelvic organs should be attempted, with conservation of some ovarian tissue if possible. For women who are approaching the menopause and whose pelvic conditions do not require operation, a menopausal dose of roentgen therapy is indicated. If, however, laparotomy is necessary and the ovaries are removed, it is then unnecessary to remove the endometrioma of the bladder. If ovarian tissue is left, then segmental resection of the endometrioma of the bladder is necessary. Endometrioma of the bladder, however, is at times so situated that excision is impossible or extremely difficult and castration is definitely the treatment of choice. As in the treatment of endometriosis in general, there are many factors to consider. In all cases, careful gynecologic examination and the opinion of a competent gynecologist are essential.

Kretschmer²³ stated that the involvement of the urinary tract by endometriosis is uncommon. The bladder, being in close proximity to the pelvic organs, may be affected. Although vesical endometriosis is rare, it occurs frequently enough that the urologist should be familiar with this pathologic condition and with the fact that the bladder may become involved.

Kretschmer reported a case of a 32 year old woman who had been having attacks of hematuria for a year. Cystoscopy revealed a bluish area on the posterior wall of the bladder. The bladder was opened, and a hard retracted area, of a bluish color and involving the vesical wall, was found. The peritoneum was opened, and the preoperative diagnosis of endometriosis was verified. A panhysterectomy was done. This confirmed the diagnosis.

The incidence of vesical endometriosis is fairly low. Smith reported that in 2 of 159 cases of endometrioma the lesion involved the bladder. Keene and Kimbrough, in 118 cases of endometriosis, found 2 cases of involvement of the bladder. Seitz observed 3 cases of vesical endometriosis among 65 cases of endometriosis. Masson reported 576 cases of adenomyoma in which operation was performed at Mayo Clinic, the total number of organs involved was six hundred and eighty-nine. In 2 of these cases, the bladder was involved. Holmes found 2 cases of endometrioma of the bladder among 145 cases of endometriosis.

²³ Kretschmer, H. L. Endometriosis of the Bladder, *J. Urol.* **53** 459-465 (March) 1945.

The occurrence of endometriosis of the urinary bladder is not confined to any particular age group. In the reported cases, the youngest patient was 18 years and the oldest was 48 years.

Hematuria when present during the menses is almost pathognomonic of endometriosis, especially in the presence of urinary frequency, dysuria and vesical irritability together with a pelvic mass. Pain may be present in the pelvis or in the lower part of the back.

As endometriosis is frequently confused with other vesical lesions, particularly malignant tumors, cystoscopic observations are diagnostic in most cases if this condition is borne in mind when the patient gives a history of cyclic symptoms. In cases of endometriosis of the urinary bladder, the so-called typical picture may not be present. However, a slightly elevated tumor with intact mucous membrane and dusky blue cystic areas resembling a varix, together with a history of periodic attacks of pain, urinary frequency, dysuria and perhaps hematuria during menstruation, are characteristic of vesical endometriosis.

The majority of the histories in the reported cases revealed that the patient had had one or more pelvic or abdominal operations before the endometriosis of the bladder was discovered.

The induction of artificial menopause by bilateral oophorectomy or irradiation of the ovaries is indicated in cases in which the patients are at or near the menopause or if there is massive involvement of the bladder which is too extensive for successful complete removal. Thus the hormone stimulation necessary for continued growth of heterotopic endometriosis is removed.

Some authors have resorted to the use of radium. Muller's patient was treated with irradiation and estradiol benzoate was given later for menopausal symptoms. When this drug was given in large doses, there was subjective and cystoscopic evidence of the endometrioma of the bladder, when smaller doses were given, the patient was largely relieved of both menopausal and vesical symptoms. If the growth involves either ureter, roentgen therapy is preferable.

Paralysis—Hanlon²⁴ described the treatment of paralysis of the bladder which follows injury of the spinal cord. This type of paralysis is seen more frequently in military than in civil practice. The management of the bladder is divided into two parts: (1) the immediate care that can be rendered near the fighting front and (2) the surgical treatment which is employed later.

The author described three methods for the immediate care of the bladder: (1) the use of an indwelling urethral catheter, (2) suprapubic cystostomy and (3) noncatheterization and manual expression of

²⁴ Hanlon, R. E. Treatment of Urinary Incontinence in Vesical Paralysis. *J. Urol.* **53**: 572-578 (April) 1945.

urine. The advantages and disadvantages of each were pointed out. The choice of method will depend on the circumstances, conditions and available facilities.

Intermittent catheterization was mentioned only to be condemned. Overdistention and overflow incontinence should be avoided.

Surgical management is designed to give the patient some degree of vesical control and thus do away with the hazards of life with an indwelling catheter or the necessity of a permanent suprapubic vesical stoma. The operation recommended—presacral sympathectomy—was adequately described.

The importance of proper postoperative management was emphasized. The postoperative regimen must be fully understood by the patient, and his cooperation must be elicited in order to obtain lasting results.

The author reported 4 cases of vesical dysfunction in which presacral sympathectomy was performed. Although the vesical dysfunction was not due to trauma in any of these cases, it was essentially similar to the vesical paralysis that follows injury of the spinal cord.

Calculi.—Price²⁵ reported his experience in North China with calculi of the bladder and reviewed 126 cases. In 121 of the cases the patients were men, and in 5 cases they were women. Seventy-four per cent of the patients were between 5 and 15 years of age, and only 7 per cent were more than 25 years. In 35 per cent of the cases the urinary symptoms began during the first three years of life, and in 72 per cent the symptoms began before the age of 7.

Intravesical obstruction was found in only 4 per cent of the cases. Three patients had stones which had formed around a foreign body in the bladder. There was no evidence from the history, physical examination or analysis of the vesical calculi that renal stone had occurred in any of these patients or that it had played a part in the pathogenesis of the disease. In fact, a renal stone was rarely observed.

Shantung is a dry region, with extremes of temperature. The water is extremely hard. It is noteworthy that the patients were freest of symptoms in hot summer months, when consumption of water is large but when the urine is likely to be concentrated.

The seasonal incidence of symptoms suggests a dietary factor in the pathogenesis. During the long winters the people, if poor, subsist chiefly on cereals, vegetable oils and vegetables poor in color. Children are commonly weaned after the second or third winter and during the next three or four years they are fed largely on cereals, especially in winter. Although in summer there is a larger variety of

25 Price, P. B. Experience with Calculus of the Bladder in North China. *Arch Surg* 50:82-86 (Feb) 1945.

foods available, even for the poor, evidences of vitamin deficiency are found commonly in patients of all ages, but especially in children. Some of the patients with a vesical stone complained of night blindness.

In most of the cases of vesical calculi, the disease was far advanced and the patients were brought to the hospital as a last resort. The duration of symptoms ranged from five days to thirty years, the average was five years. A history of attacks with symptom-free intermissions was characteristic.

In an advanced stage of the disease, the symptoms were so typical that the diagnosis was rarely in doubt.

In 30 per cent of cases, the stone or stones could be felt through the rectum. The ability to do so usually indicated a large stone fixed in position by a contracted bladder, by adhesion to the bladder wall or by impaction in the prostatic portion of the urethra.

Roentgenographic examination rarely failed to provide reliable and accurate information regarding the number, size, position and even structure of the stones. Two patients had stones which cast no shadows. Multiple calculi were not uncommon, but the usual finding was a single large calculus. The largest stone encountered was hourglass in shape and 9 cm. long and weighed 235 Gm. The patient had had symptoms for thirty years.

Because of the poor physical condition of many of the patients, emphasis was laid on unhurried, adequate preoperative care. Rest in bed, sedation, use of an indwelling urethral catheter, gentle irrigations and instillations, administration of urinary antiseptics by mouth, institution of a high caloric diet, treatment of anemia and intestinal parasites, correction of fluid and electrolytic balances and general nursing care seldom failed to bring about pronounced general improvement. Especially important was employment of the indwelling catheter, if properly placed, it usually relieved the pain and spasm to a large extent and provided for the all-important free drainage of urine.

Price described minutely his method of suprapubic lithotomy.

In 12 cases the bladder was drained suprapubically after removal of the stones. Hospitalization averaged sixty days, and an average of forty days was required before leakage of urine from the incision ceased entirely. All the patients had an uncomfortable, and some of them a stormy, convalescence. Two died.

In 36 cases the bladder was closed without drainage. In these cases the patients were in the hospital an average of thirty-one days. In 70 per cent of the cases the wounds became infected to a greater or less extent, and postoperative leakage of urine from the incision occurred in 66 per cent of the cases. Healing without leakage or infection

tubing was employed, death generally followed from hemorrhage due to erosion of the wall of the vessel. When a Goldblatt silver clamp was used, the animal usually died because of too great constriction or hemorrhage or accumulation of fluid in the pleural cavity.

The negative results of these experiments should have been and were anticipated in the light of the previous experiences of others. For example, the following sentences contain some of the conclusions of Haggart and Walker¹: "Until from 52 to 66 per cent of the pulmonary circulation is cut off there is no significant variation in the general circulatory condition of the animal. The point at which failure occurs is sharply defined, since beyond this endpoint a circulatory collapse is precipitated by a minute increase in the arterial obstruction, but if this is not applied no untoward change results." At any rate, it appeared that some other method would have to be used if the effects of an artificial ductus arteriosus were to be tested.

PNEUMONECTOMY AND CREATION OF PULMONARY ARTERIOVENOUS FISTULA

The next procedure which was used consisted in the removal of the entire right lung and the performance of an end to end anastomosis between the proximal end of the right pulmonary artery and the proximal end of a major right pulmonary vein. The blood which was pumped by the right side of the heart to the right pulmonary artery returned to the left side of the heart without being oxygenated. In most of these dogs, polycythemia, arterial unsaturation and cyanosis developed. The following results were obtained in one of the experiments. A comparison of the preoperative values with those obtained three months later shows that the hematocrit reading rose from 48 to 67, the red blood cell count rose from 4,800,000 to 7,200,000 per cubic millimeter, the oxygen content of arterial blood rose from 21 to 23 volumes per cent and the oxygen saturation of arterial blood declined from 95 to 75 per cent. These animals showed an increase in blood volume, which was due to the increase in the volume of red blood corpuscles. Most of the animals were dyspneic on slight exertion, and the mucous membranes were of a reddish blue color.

The alterations in the arterial saturation in these animals were of the order that had been sought, but unfortunately the absence of one entire lung made it difficult or impossible to test the effects of the creation of an artificial ductus arteriosus. It was then decided that parts of one or both lungs should be removed and that unilateral or bilateral pulmonary arteriovenous fistulas should be created. The presence of

¹ Haggart, G. E., and Walker, A. M. The Physiology of Pulmonary Embolism as Disclosed by Quantitative Occlusion of the Pulmonary Artery, *Arch. Surg.* 6:764 (May) 1923.

residual pulmonary tissue on both sides would allow one to interrupt the circulation to one of the two sides while the pulmonary artery on this side was being anastomosed to a branch of the aorta

LIMITED PULMONARY RESECTION COMBINED WITH PULMONARY ARTERIOVENOUS FISTULA

A total of 36 experiments employing pulmonary resection combined with pulmonary arteriovenous fistula were performed. The procedure varied somewhat, but the method used most often consisted at the first operation in the removal of the diaphragmatic and intermediate lobes of the right lung and the performance of an end to end anastomosis

Effect on Arterial Saturation of the Creation of an Artificial Ductus Arteriosus

Days	Hematocrit Reading, %	Arterial Oxygen Content, Vol %	Arterial Saturation, %
0	56.0	23.8	95.0
3	Diaphragmatic and intermediate lobes of right lung removed pulmonary arteriovenous fistula created		
25	41.0	18.2	82.5
37	38.3	18.7	82.0
48	Hypertrophied left lower lobe removed no fistula created		
68	68.8	12.2	46.4
69	69.0	13.2	52.5
69	Artificial ductus between end of subclavian artery and side of left pulmonary artery		
76	51.4	19.0	80.5
83	36.5	17.2	79.5
96	47.5	16.9	72.8
123	37.9	16.1	72.6
164	32.0	12.6	72.4
200	33.2	14.3	76.3
239	39.0	15.3	74.1
277	38.3	15.7	78.8

between the proximal ends of the severed pulmonary artery and vein. The dog has four lobes on the right and three on the left. If the dog survived this initial operation and if the resulting degree of arterial unsaturation was less than was desired, the procedure was repeated on the left side, the lower lobe being removed and the artery and vein being united by sutures. In the 36 experiments, a total of one hundred and eight lobes were removed and fifty-three pulmonary arteriovenous fistulas were created. Most of the animals died during or after the second procedure, in which additional pulmonary tissue was removed and a

second fistula created. An attempt was being made to produce a severe degree of arterial unsaturation, such as is seen in many children with pulmonary stenosis, namely, 60 to 75 per cent unsaturation. It was decided subsequently that a less severe degree of unsaturation would be adequate for the purpose. It is of interest, however, that arterial saturations of 32, 34, 35 and 42 per cent were produced in 4 of the experiments, but the animals died before or during an attempt to create an artificial ductus arteriosus.

There were only 6 experiments in which a rather pronounced degree of oxygen unsaturation of arterial blood has been produced and in which an artificial ductus arteriosus has been successfully created. Only a slight increase in arterial oxygen saturation occurred following the making of the artificial ductus in 2 of the animals. There was a significant elevation of the arterial saturation in the remaining 4 animals. The proximal end of the divided left subclavian artery was anastomosed to the side of the left pulmonary artery in 4 of the experiments. In the remaining 2, the end of the innominate artery was anastomosed to the side of the right pulmonary artery. Some of the details of 1 of the experiments are given in the table. The arterial oxygen saturation rose from 52 to 80 per cent following the creation of an artificial ductus, and the arterial oxygen capacity declined from 27 to 22 volumes per hundred cubic centimeters.

COMMENT

Cyanosis is due to the presence of reduced hemoglobin in the circulating blood. Lundsgaard and Van Slyke² showed that there are four important factors in the production of cyanosis: (1) the total hemoglobin content, (2) the degree of oxygen unsaturation of the arterial blood coming from aerated pulmonary areas, (3) the proportion of blood passing from the right side of the heart to the left through unaerated channels and (4) the oxygen consumption in the capillaries.

In the experiments reported on here, in which pulmonary tissue was removed and a pulmonary arteriovenous fistula created, it seems that the main reason for the arterial unsaturation is the return of unoxygenated blood through the fistula directly to the left side of the heart. The total hemoglobin was not greatly increased in these experiments, and there is no reason to believe that the degree of oxygen unsaturation of the arterial blood coming from the remaining pulmonary tissue or

² Lundsgaard, C., and Van Slyke, D. D. Cyanosis, *Medicine* 2:1 (Feb) 1923.

the oxygen consumption in the capillaries of the body was grossly abnormal. The relationships in patients with the tetralogy of Fallot are complex, and there are a number of reasons for the arterial unsaturation and the resulting cyanosis. These were discussed in a recent paper by Dr. Taussig and me.³ The fact that there is a defect in the interventricular septum and that the aorta overrides the septum results in the passage of some unaerated blood into the aorta. It is mainly in this respect that the experimental condition here reported resembles the tetralogy of Fallot.

In these experiments the creation of an artificial ductus arteriosus was followed in most instances by an increase in the oxygen saturation of the arterial blood. This increase was due to the passage of a greater quantity of blood which was not fully oxygenated through the pulmonary capillaries. If the cardiac output remained unaltered, a greater number of red blood corpuscles were exposed to the inspired air in a given unit of time. Although this experimentally produced condition is different from that seen in the patient with the tetralogy of Fallot, the results of these studies strengthened the impression of Dr. Taussig that the patient with pulmonary stenosis would be improved if the pulmonary blood flow were increased and led to the development of the operation⁴ as now performed on patients with pulmonary stenosis or atresia.

SUMMARY

These experimental studies were performed in an effort to determine whether the creation of an artificial ductus arteriosus would be helpful in the treatment of pulmonary stenosis or atresia in patients. Attempts to produce the desired degree of pulmonary stenosis were unsuccessful. Unilateral pneumonectomy and the anastomosis of the proximal ends of the pulmonary artery and vein resulted in a high degree of oxygen unsaturation of arterial blood, but this preparation was unsatisfactory for testing the effects of an artificial ductus arteriosus. The removal of lobes of one or both lungs and the anastomosis of the severed proximal ends of the pulmonary artery and vein usually resulted in a high degree of arterial oxygen unsaturation of arterial blood, but this preparation was unsatisfactory for testing the effects of an artificial ductus arteriosus. The removal of lobes of one or both lungs and the

3 Blalock, A., and Taussig, H. B. The Surgical Treatment of Malformations of the Heart in Which There Is Pulmonary Stenosis or Pulmonary Atresia. *J. A. M. A.* 128:188 (May 19) 1945.

anastomosis of the severed proximal ends of the pulmonary artery and vein usually resulted in a high degree of arterial oxygen unsaturation because some venous blood returned to the heart without having passed through pulmonary capillaries. The creation of an artificial ductus arteriosus under these conditions usually resulted in an increase in the oxygen saturation of the arterial blood. The possible relationship of these observations to the treatment of pulmonary stenosis in patients is discussed.

Dr. Helen Taussig gave helpful advice.

SUBMUCOSAL LIPOMAS OF THE STOMACH

A Review of the Literature and Report of a Case Associated with Carcinoma

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IN the last decade there has been an increasing interest in the problems associated with the benign tumors of the stomach. In the past such lesions have been considered as relatively rare. Although reports now indicate that they occur with greater frequency than previously supposed¹ a few of the types of benign tumors may still be considered as rare, and, of these, one of the least is the submucosal lipoma.

In 1893 Tilger² emphasized the rarity of this tumor, when he reported from a series of 3,500 autopsies 14 benign gastric tumors, 2 of which were submucosal lipomas. Eliason and Wright³ in summarizing 610 collected and personal cases of benign gastric tumors, noted 30 lipomas of the stomach, including 1 from their own cases. Stewart⁴ found no submucosal lipomas in a series of 11,000 autopsies. Minnes and Geschickter⁵ mentioned 32 cases in a series of 981 collected and personal cases of benign gastric tumors. Rumold⁶ in a review of the literature from 1835 to 1940 was able to find 32 cases and added 1 case of his own, bringing the total to 33. Since then, several cases have been reported. We wish to review briefly these recent cases and to

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1 Dudley, G. S., Miscall, L., and Morse, S. F. Benign Tumors of the Stomach, *Arch. Surg.* **45**: 702 (Nov.) 1942. Dewey, E. B. Benign Tumors of the Stomach, *Am. J. Surg.* **65**: 233 (Aug.) 1944.

2 Tilger, A. Ueber primäres Magensarcom, *Virchows Arch. f. path. Anat.* **133**: 183, 1893.

3 Eliason, E. L., and Wright, V. W. M. Benign Tumors of the Stomach, *Surg., Gynec. & Obst.* **41**: 461, 1925.

4 Stewart, M. J. Observations on the Relation of Malignant Diseases to Benign Tumors of the Intestinal Tract, *Brit. M. J.* **2**: 567, 1929.

5 Minnes, J. F., and Geschickter, C. F. Benign Tumors of the Stomach, *Am. J. Cancer* **28**: 130, 1936.

6 Rumold, M. H. Submucous Lipomas of the Stomach, *Surgery* **10**: 242, 1941.

report a case of a submucous lipoma of the pylorus associated with an infiltrative adenocarcinoma. In doing so, we have reproduced Rumold's⁶ tabulation of cases and have added to it the more recent cases, including our own (see the table). Because the descriptive data were insufficient, this does not include the 3 cases mentioned by Bouvier.⁷

Summary of Cases of Submucosal Lipomas of the Stomach

Case	Year	Author	Sex	Age, Yr	Discovery	Size	Clinical Features
1	1835-1842	Oruvelbier			Autopsy	"Almond"	
2	1863	Virchows	M		Autopsy	"Hazelnut"	
3	1889	Murray		64	Autopsy		
4	1893	Tilger		High age	Autopsy	"Hazelnut"	
5	1893	Tilger		High age	Autopsy	"Hazelnut"	
6	1905	Bensky	M	60	Autopsy	6 by 3, 5 by 2 cm	
7	1905	Fischer	F	37	Resection	"Walnut"	Pains in umbilical region, gastric juice normal
8	1908	Hellstrom	M	77	Autopsy	"Hazelnut"	Free from symptoms
9	1911	Westenhoeffer			Autopsy		
10	1912	Randisl	M	65	Resection	'Triangular prismatic tumor'	Epigastric pains, vom- iting, emaciation of 23 months duration
11	1922	Verger and Massias	F	53	Autopsy	"Hazelnut"	Anorexia, nausea, diarrhea, emaciation cachexia
12	1924	Nahmmacher	F	65	Autopsy	8 by 3, 5 by 3 cm	
13	1925	Ellason and Wright	M	52	Autopsy	Solitary tumor in fundus	
14	1926	Blanchl	F	57	Autopsy		Vomited for 12 mos
15	1926	Spitzmuller	M	69	Resection	"Tangerine"	Palpable tumor blood in stools, pain after meals
16	1928	Welcker	M	60	Resection	Small apple"	Pains after meals, sometimes vomiting, achylia, roentgeno- graphic defect, emaciation
17	1929	White and Judd	F	59	Resection	5.5 by 3, 3 by 2.3 cm	Attacks of fatigue, roentgenographic defect, hemorrhage, tarry stools
18	1930	Neumann	F	63	Resection	15 by 4 cm	Mild eructations roentgenogram reveals tumor in cardia
19	1931	Comfort	M	67	Autopsy	9.5 by 4.5 cm	
20	1931	Comfort	F	65	Autopsy	8 mm diameter	
21	1931	Comfort	M	74	Autopsy	1 by 2 by 3.5	
22	1933	Mandl and Vogl	M	43	Excision	"Pedicled tu- mor, larger than nut"	History of ulcers
23	1933	Pansdorf and Determann	F	65	Resection	Broad based 1 cm in diameter	Weber's test positive in feces roentgeno- gram reveals benign tumor
24	1944	Melchior	M	57	Resection	'Oscillating tumor size of cherry	Weber's test positive, symptoms simulating cholecystitis
25	1934	Santy	F	40	Resection	"Tangerine"	Anemia, pains after food, vomiting, Weber's test of feces positive

⁷ Bouvier, E. Ueber die benignen Tumoren des Magendarmtraktes, Arch f klin. Chir **131** 162, 1924

Summary of Cases of Submucosal Lipomas of the Stomach—Continued

Case	Year	Author	Sex	Age, Yr	Discovery	Size	Clinical Features
26	1935	Glass	M	30	Resection	"Broad based tumor size of fist"	Epigastric pain, black stool Weber's test positive in feces
27	1935	Kirschbaum, J.D Ann. Surg 101 : 734, 1935	F	75	Autopsy		
28	1935	Trolsier			Autopsy	"Ten tumors, largest size almond"	Anemia, profuse hemorrhage
29	1936	Kentorovitch	F	29	Resection	"Size of kidney"	Nausea and vomiting roentgenogram showed benign tumor
30	1937	Metivet	M	69	Resection	20 cm in diameter	Blood in stools, roentgenogram showed probably benign tumor
31	1938	Redell	F	33	Resection	167 Gm., "twice the size of a hen's egg"	Black stools anemia, Weber's test of stools positive
32	1938	Garre, Garelik and Chiarlo	M	50	Resection	9 by 4 cm	Eruptions, abundant hematemesis
33	1939	Jorns, G Chirurg 11 : 840, 1939	M	40	Resection	Oscillating, 3 by 3 cm	18 year history of distress with fullness after meals, roentgenogram showed constant filling defect blood in stools
34	1940	Knetsch, A Röntgenpraxis 12 : 159, 1940	M	48	Resection	"Walnut sized"	Epigastric fullness, nausea and emesis after meals, roentgenogram showed constant filling defect in angulus
35	1940	Rumold.	F	47	Resection	7 5 by 5.5 by 5 cm	Eructations, blood in stools, nausea, vomiting, anemia, achlorhydria
36	1944	Sobezyk	F	54	Excision	7 by 2 by 3 cm	Epigastric pain, anemia tarry stools palpable mass, roentgenogram showed filling defect
37	1942	Cattell.	F	37	Resection	6 cm in diameter	Fatigue and epigastric fullness after eating hematemesis, tarry stools, roentgenogram showed filling defect
38	1942	Daza and Zuniga	F	43	Resection	3 cm in diameter	Gastric distress periodic since infancy, epigastric fullness and burning after meals, hypochlorhydria, tarry stools, roentgenogram showed filling defect
39	1945	Scott and Brunschwig	M	59	Resection	1 5 by 2 cm	Pain in epigastrium vomiting, loss of weight, achlorhydria roentgenograms showed obstructive lesion in pylorus

REPORT OF A CASE

F O, a 59 year old Italian man, was admitted to the University of Chicago Clinics on June 27, 1945, complaining of epigastric pain, of three months' duration, associated with vomiting and a 15 pound (6.8 Kg) loss of weight.

Inquiry revealed that he had a similar episode in 1941. Roentgenograms at that time were said to show gastric ulcer. The patient was treated with powders, milk and cream, and within two months his symptoms had disappeared. In 1942

and 1943 he had recurrence of symptoms, and on each occasion complete remission of symptoms was obtained with medical management. The last episode, which led to his admission to the hospital, began in March 1945, at which time he began to have epigastric pain, which characteristically appeared about two hours after meals and often awakened him at night. Occasionally he would vomit large volumes of a foul gray material. Relief from symptoms could be obtained by



Fig 1—Surgical specimen consisting of lower portion of stomach opened along greater curvature and showing C, infiltrating carcinoma (bisected), and L, sessile submucosal lipoma distal to the neoplasm



Fig 2—Cut edge of specimen shown in figure 1. L, cut surface of submucosal lipoma covered by intact gastric mucosa, C, cut edge of carcinoma in pyloric region

belching or emesis or from the use of powders and milk and cream. There was no history of hematemesis or melena.

Physical examination revealed a chronically ill patient, who was having moderate epigastric distress. There was mild tenderness and a sense of resistance

to palpation in the epigastrium. Visible gastric peristalses were noted. The examination was otherwise noncontributory. Examinations of the blood and urine, including studies of blood chemistry, gave essentially normal results. Achlorhydria was demonstrated by a histamine test. Gastroduodenal roentgenologic studies were reported as follows: "On fluoroscopic examination the esophagus appeared normal. An obstructive lesion was present in the pyloric region for 3 to 4 cm proximal to the duodenal bulb. This area was so narrow that barium sulfate was forced through only with great difficulty and in insufficient quantity to visualize the particular area during the passage of the barium. The duodenal bulb appeared normal. The impression was a constricting lesion of the pylorus causing severe obstruction, presumably due to carcinoma."

"Gastrosopic examination revealed an ulcerating polypoid mass extending as far as the angulus and hidden in the prepyloric area. The impression was a gastric carcinoma."

On July 3, 1945 the abdomen was opened through a high midline incision. An infiltrating lesion was palpated in the prepyloric region, and at the lower portion there seemed to be a boggy mass within the stomach and protruding into the duodenum for about 2 cm. The stomach was mobilized, and a partial gastrectomy with a Polya type of posterior gastrojejunostomy was done. Recovery was uneventful, and the patient was discharged on the seventeenth postoperative day.

The report of the pathologic examination was as follows: The specimen consists of the distal two thirds of the stomach, measuring 12 and 15 cm along the lesser and greater curvatures respectively, and a small piece of attached mesocolon. The wall of the stomach seems diffusely thickened and is covered with small hemorrhagic spots. The pyloric end is thickened and indurated, and when this area is cut through a firm, gray-white tissue is encountered. Inspection of the mucosal surface reveals in the prepyloric region a flat shallow ulcer about 5 cm wide in its greatest diameter. Beyond the lower margin of this ulcer and protruding into the pylorus is a soft sessile mass. This measures about 1.5 cm in diameter and projects for about 2 cm into the lumen, so that it occupies almost the entire pyloric canal. Section through this mass shows it to consist of fatty tissue (figs 1 and 2).

"Microscopic examination of tissue from the ulcerated region reveals groups and strands of malignant epithelial cells infiltrating throughout the muscularis. Acinar formation is common. A section of the mass within the pylorus shows it to consist entirely of mature adipose tissue, which lies just beneath the mucosa. The muscularis at the base of this lesion is infiltrated by carcinoma. The pathologic diagnosis was infiltrative adenocarcinoma of the stomach and submucosal lipoma of the pylorus."

COMMENT

The cause of the lipomas of the intestinal tract remains unknown. Some authors have suggested the possibility of congenital influences since a familial pattern was noted by Rumold⁶ in his case of submucous lipoma of the stomach in a patient who had a brother, a sister and two nephews, all of whom had lipomas of the extremities. Daza and Zuniga⁸ cited a patient who had periodic episodes of gastric distress from infancy. In addition to a submucosal lipoma of the stomach, she had a lipoma in the right lumbar region. The sex incidence is apparently

8 Daza and Zuniga. Lipom submucoso del antro herniado al duodeno, *Rev. med. de Chile* 70: 799, 1942.

equal, and in the 39 case records now available the age incidence varies from 29 to 77 years

The lipomas of the stomach may be either subserosal or submucosal and may be single or multiple. The submucosal types vary from a few millimeters to several centimeters in diameter and may be sessile or pedunculated. Cattell⁹ recorded an unusual instance in which the tumor projected through the gastric wall along the course of vessels, producing a dumbbell-shaped mass. Although their position is variable, they often occur in the region of the pylorus and may produce obstructive symptoms. Overlying the tumor the mucosa is usually smooth, but ulceration is not uncommon. Schindler¹⁰ found that a fairly constant feature of submucosal tumors is the stretching of adjacent rugae so that they appear to bridge the space between the top of the tumor and the surrounding mucosa. Grossly and microscopically these tumors have the characteristics of adipose tissue, with some degree of lobulation.

The clinical picture of the submucosal lipomas of the stomach is variable but not unlike that of other benign gastric tumors. Of the 39 cases now available for study, 22 were operative cases and 17 were reported from autopsies. Clinical data are available on only 2 of the cases brought to autopsy. Hellstrom¹¹ reported 1 patient as having been free from symptoms. Several of the clinical aspects of the 22 operative cases warrant discussion. Hemorrhage, either severe or of a chronic low grade type, was noted in 15 instances. Thirteen of the patients complained of pain or of a sense of fullness, and in 10 cases nausea and vomiting were prominent features. Obstructive symptoms may occur, depending on the location of the lesion. In our own case, the lipoma occupied almost the entire pyloric canal. Daza and Zuniga⁸ reported a case of submucosal lipoma of the antrum which herniated into the duodenum. In only 2 of the recorded cases was a tumor palpable (Spitzmuller¹² and Sobezyk¹³).

The preoperative diagnosis of benign gastric tumors can often be made by roentgenographic and gastroscopic examinations. As pointed out by Moore,¹⁴ there are certain roentgenologic signs that are suggestive of benign tumors.

9 Cattell, R. B. Lipoma of the Stomach Causing Hemorrhage, *Lahey Clin Bull* 3 34, 1942.

10 Schindler, R., Sandweiss, D. J., and Mintz, I. L. Benign Submucosal Tumors of the Stomach. Gastroscopic Study, *Am J Digest. Dis* 9 289, 1942.

11 Hellstrom, N. Kasuistische Beiträge zur Kenntnis des Intestinallipoms, *Deutsche Ztschr. f. Chir.* 84 488, 1906.

12 Spitzmuller, W. Ein Fall von Magenlipom, *Wien klin. Wchnschr.* 39 538, 1936.

13 Sobezyk, P. Benign Tumors and Ulcers with Reference to Submucous Lipomas, *Zentralbl. f. Chir.* 68 408, 1941.

1 They produce a filling defect that is well circumscribed and punched out in appearance

2 The filling defect is usually on the gastric walls, leaving the curvature regular and pliant.

3 While the rugae are often obliterated in the immediate area of inflammatory or malignant lesions, the rugae surrounding a benign tumor are nearly normal in their arrangement and distribution

4 They cause little or no disturbance in peristalsis, and retention is uncommon except when the lesion is at or near the pylorus

5 They do not reveal a niche, nor is there any incisura or evidence of spasm

6 They are rarely sufficiently large to be palpated

Schindler¹⁰ emphasized the gastroscopic appearance of benign submucosal tumors. He stated that there is "one sign not compatible with a mucosal tumor and permitting the diagnosis of a submucosal tumor, namely, the stretching of a mucosal fold from the surrounding mucosa up to the surface of the tumor, apparently bridging the space between the top of the tumor and the level of the surrounding mucosa." Both Schindler¹⁰ and Rumold⁸ have published excellent photographs which demonstrate this characteristic.

The treatment of the submucosal lipomas of the stomach does not differ from that of the other benign gastric tumors. Although local excision may suffice, Rumold emphasized that a portion of the involved gastric wall should be excised to avoid the possibility of recurrence.

The occurrence of both carcinoma and lipoma in the stomach, described by us, is coincidental, as submucosal lipoma is to be regarded neither as a premalignant condition nor as evidence of carcinogenic factors in operation.

SUMMARY

A brief review of the literature has been made, and 6 cases of submucosal lipoma of the stomach have been added to Rumold's tabulation of cases, bringing the total number of reported cases to 39. This includes our own case, in which the lipoma was associated with an adenocarcinoma.

The clinical and pathologic aspects of the submucosal lipomas of the stomach are discussed.

14 Moore, A. B. A Roentgenologic Study of Benign Tumors of the Stomach, *Am J Roentgenol* **11** 61, 1924.

A BASIS FOR SYMPATHECTOMY FOR CANCER OF THE CERVIX UTERI

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IN RECENT years several attempts have been made to relieve pain in certain cancerous diseases through action on the sympathetic nervous system. By blocking the sympathetic pathways with an anesthetic solution or by surgical interruption, the fibers conducting painful sensations arising in the area involved in the neoplasia are interrupted and the painful stimulations originated in the tumoral area cannot reach the cerebrospinal centers. In this way can be relieved the visceral pain of tumors located in such organs as the uterus, stomach, pancreas and breast. One must remember, however, that the sympathetic approach relieves pain only in the region whose sympathetic innervation has been interrupted, if the tumor grows and invades the adjacent organs beyond the area anesthetized by section of the sympathetic innervation, the painful sensations will reappear. This is true also if the tumor keeps within the anesthetized visceral area but a metastasis develops in a distant region, where a new neoplastic focus will be a point at which new sensations of pain may arise. The results obtained by certain authors (Leriche¹, Greenhill²) and by me and my associates in the treatment of visceral pain due to cancer clearly show that it is possible, by action on the sympathetic system, to relieve the pain of these unhappy patients in certain cases.

When the sympathetic nerves that innervate the visceral area in which the tumor is located are interrupted, not only the pathways of the painful sensations but also the vasomotor pathways in the same area are removed. Section of the vasomotor innervation is followed by vasodilatation in the area of the tumor, and this increases the nutrition of the neoplastic tissues and multiplication of the tumor cells. In short, there is a double effect when the sympathetic innervation is interrupted: (1) relief of pain by interruption of the pathways of painful sensations and perhaps also by relief of vascular spasm and, (2) vasodilatation from interruption of the vasomotor innervation.

1 Leriche, R. The Surgery of Pain, translated and edited by A. Young, Baltimore, Williams & Wilkins Company, 1939.

2 Greenhill, J. P. Control of Pain in Cases of Cancer, M. Clin. North America 25 117, 1941.

Is it possible to relieve the pain by interruption of the sympathetic pathways and at the same time prevent the adverse influence of the local increase of circulation by postoperative physical therapy?

To study this important problem I have investigated a series of cases of cancer of the cervix uteri. In the Portuguese Institute of Oncology, a group of patients with cancer of the cervix uteri were treated by radium and by daily repeated anesthetic blocks of the lumbar sympathetic chain. The results for these patients were compared with those for a similar series treated with radium therapy alone, *i. e.*, without the interruption of the sympathetic innervation of the uterus. The results of these investigations are the basis of this study. In addition, investigations were made to determine the pathways and the mechanism of painful sensations in carcinoma of the cervix uteri and the vasomotor influence of the sympathetic innervation on the organs in the pelvis and the lower extremities.

PAIN IN CARCINOMA OF CERVIX UTERI, MECHANISM AND PATHWAYS OF THE PAINFUL SENSATIONS

In carcinoma of the cervix uteri, pain is felt when the adjacent structures in the pelvis have been invaded. Pain referred to the lower extremities occurs only when extension of the cancer has involved the adjacent nerves (Cutler and Buschke³). It is admitted that the neoplastic invasion of the ligamentous supporting structures of the uterus frequently produces a dull aching pain in the back that may radiate anteriorly to the groin. When constant dull pain occurs in this region, it is thought to be due to the invasion of the broad ligaments (Graves⁴). The occlusion of the ureter by extension of the cancer may also induce pain.

In the following analysis of the mechanism of pain in carcinoma of the cervix uteri, I have excluded the localized and fixed prevertebral pain due to compression of the nerve trunks and also the spinal pain provoked by localized metastases. The treatment by posterior radiotomy or cordotomy is indicated for involvement of the cerebrospinal nervous system. In this study, only the pain of a diffused type produced by the stimulation of the sympathetic innervation of the uterus and adjacent structures will be considered.

In a series of 10 cases of carcinoma of the cervix uteri, I investigated the sympathetic mechanism of pain by blocking the innervation of the organs of the pelvic cavity with procaine hydrochloride. The patients had been treated previously by radium and roentgen rays, and

3 Cutler, M., and Buschke, F. *Cancer: Its Diagnosis and Treatment*, Philadelphia, W. B. Saunders Company, 1938.

4 Graves, cited by Cutler and Buschke.³

in every case this treatment was followed by healing of the cervix. In all cases, however, continuous and diffuse pain low in the back and in the abdomen radiating to the left groin persisted. These patients were all submitted to repeated anesthetic blocks of the lumbar sympathetic chain at the level of the first, second and third lumbar ganglions unilaterally or bilaterally.

In 6 patients the pain was relieved from one to one and a half hours, after which it returned with the same intensity as before. In 1 patient the repeated anesthetic blocks caused a reduction of the edema of the left lower extremity and relieved the pain low in the abdomen but a slight pain persisted at the level of the left sacroiliac joint. In 3 other patients, relief of pain lasted twenty days in 1 and fifty days in another, in the third, who had begun to feel slight pain low in the back and low in the abdomen nine years after the radium treatment, the pain was relieved for four and a half months.

How are such different results following the same method of interruption of the sympathetic pathways of the organs of the pelvic cavity to be explained? Possibly in those patients in whom the repeated anesthetic blocks relieved the pain for only one to one and a half hours, i. e., the time corresponding to anesthesia by infiltration, an organic and permanent stimulation of the sympathetic innervation from invasion of the tumor was responsible.

However, the results observed in the last 3 patients suggest that another mechanism may be responsible for the pain in carcinoma of the cervix uteri. The relief of pain for a period exceeding the normal anesthetic action of the procaine hydrochloride suggests the participation of another factor, possibly vascular. It is known that when the sympathetic chains are interrupted beyond the section of the afferent pathways interruption of the efferent pathways also results, and this is followed by vasodilatation, which is maintained longer than the period of anesthesia. On the other hand, it is claimed by some (Leriche⁵, Campbell⁶) that vasoconstriction may cause pain. The neoplastic lymphangitis stimulates the perivascular innervation to produce vasoconstriction and may also induce pain. Hence one can suppose that pain will disappear when the vasoconstriction is relieved by anesthetic block.

In patients with carcinoma of the genital organs, I have endeavored to learn whether stimulation of the lymph nodes and of the lymphatic vessels by a chemical drug will cause pain and also whether the afferent pathways pass through the sympathetic system. In 3 patients, 1 to 3 cc

5 Leriche, R, and Stricker, P. *Recherches experimentales sur le nerf pre-sacré*, Bull et mem Soc nat de chir **53** 819, 1927.

6 Campbell, W G. *Role of Sympathetic Nervous System in Segmental Pain*, Lancet **2** 930 1939.

of Uroselectan (sodium 2-oxo-5 iodopyridine-N-acetate), which is opaque to roentgen rays and slightly irritative to the lymph vessels, was injected into a lymph node of the groin. The injection was followed by diffuse pain in each patient. During the injection roentgenograms were taken to find out whether the drug had been taken into the lymph nodes and the lymph vessels only (fig 1). Then the lumbar sympathetic chain was blocked at the level of the second and third lumbar ganglions and in a few minutes the pain had been completely relieved.

Moreover, in phlebitis and after mechanical stimulation of the innervation of a femoral vein or artery, I have observed the relief of pain



Fig 1—Lymphangiogram of the lymph nodes and lymph vessels in patients during the injection of Uroselectan into a lymph node of the groin. The injection was followed by diffused pain that was relieved in a few minutes after the anesthetic block of the lumbar sympathetic chain. 1, lymph node, 2, lymph vessel.

by anesthetic block of the lumbar sympathetic chain. These facts suggest that the stimulation of the perivascular innervation of the lymphatic vessels, veins and arteries by inflammatory or neoplastic lymphangitis may also be a cause of pain in carcinoma of the cervix uteri.

PATHWAYS OF PAINFUL SENSATIONS OF THE UTERUS

The afferent pathways that conduct painful sensations of the uterus follow a course that must be known in order to treat the pain resulting

from carcinoma of the cervix uteri Cotte,⁷ in 1925, showed that section of the presacral nerves abolishes the pain of dysmenorrhea produced by contraction of the uterus Leriche and Stricker⁸ (1927) stimulated the intact presacral nerve or the central end of the sectioned nerves in dogs, and the stimulations provoked caused the dogs to awaken from deep general anesthesia, the animals groaned as if suffering from intense pain Fontaine and Herrmann⁸ agreed that the hypogastric plexus carries the important pathways of sensation from the internal genital organs to the medullary centers They pointed out that interruption of the superior hypogastric plexus is a safe, simple and effective way to treat the functional type of dysmenorrhea and to relieve other forms of severe pelvic pain In 22 cases of dysmenorrhea or pelvic plexalgia, they came to the conclusion that resection of the presacral nerve was followed by full and lasting relief from pelvic pain in the great majority of the cases

The investigations of Leriche,⁹ employing periarterial sympathectomy of the hypogastric and ovarian arteries, also suggested the role of the innervation of these vessels in pelvic pain

The problem of the afferent pathways conducting the painful sensations of the uterus was recently investigated by Cleland,¹⁰ who demonstrated that labor pains, due to uterine contractions, are transmitted by afferent fibers that pass through the eleventh and twelfth thoracic roots and concluded that paravertebral block of the eleventh and twelfth thoracic roots will abolish pain from uterine contraction for periods that varied with the type of anesthetic used The results of Shumacker, Manahan and Hellman¹¹ (1943) and Jarvis¹² (1944) with anesthetic block of the lumbar sympathetic chain in the treatment of labor pains supply evidence that the afferent pathways that conduct painful sensations of the uterus pass through the lumbar sympathetic chain before reaching the eleventh and twelfth thoracic roots

The results of my experiments with anesthetic block of the lumbar sympathetic chain in the treatment of pain in cancer of the uterus

7 Cotte, G La sympathectomie hypogastrique a-t-elle sa place dans la therapeutique gynécologique? *Presse méd* **33** 98, 1925

8 Fontaine, R, and Herrmann, L G Clinical and Experimental Basis for Surgery of the Pelvic Sympathetic Nerves in Gynecology, *Surg, Gynec. & Obst* **54** 133, 1932

9 Leriche, R Resultats de la sympathectomie faite sur les artères hypogastrique et ovarienne en gynécologie, *Presse med* **33** 465, 1925

10 Cleland, J G P Paravertebral Anaesthetic in Obstetrics, *Surg, Gynec & Obst* **57** 51, 1933

11 Shumacker, H B, Manahan, C P, and Hellman, L M Sympathetic Anesthesia in Labor, *Am J Obst & Gynec.* **45** 129, 1943

12 Jarvis, S M Paravertebral Sympathetic Nerve Block A Method for the Safe and Painless Conduct of Labor, *Am J Obst & Gynec* **47** 335, 1944

confirm the results observed in the relief of labor pains. In cases of carcinoma of the cervix uteri, I observed that the anesthetic block with procaine hydrochloride at the level of the first, second and third lumbar ganglions was followed by relief of pain—i.e., the afferent pathways of painful sensations of the uterus were temporarily interrupted at these levels in the lumbar sympathetic chain.

Finally, these results demonstrate that the afferent pathways of painful sensations of the uterus reach the eleventh and twelfth thoracic roots through the hypogastric plexus and the lumbar sympathetic chain (fig. 2)

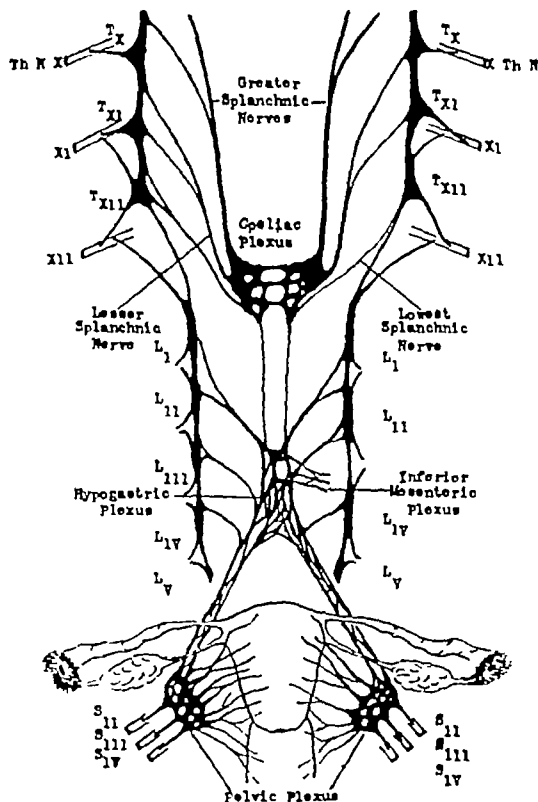


Fig. 2—Sympathetic innervation of the uterus

INVESTIGATIONS CONCERNING THE INFLUENCE OF ABDOMINO-PELVIC SYMPATHECTOMY AND ANESTHETIC BLOCK ON THE ARTERIAL CIRCULATION OF THE PELVIS AND LOWER EXTREMITIES

To determine the vasomotor influence of the abdominopelvic sympathectomy on the development of collateral arterial circulation in the pelvis and in the lower extremities, a series of experiments on animals has been performed. In 46 dogs, studies were made on the influence of the various types of abdominopelvic sympathectomies on the development of arterial circulation in the pelvis and in the

lower extremities after ligation of the hypogastric arteries. With the animals under general ether anesthesia, a paramedian and retroumbilical incision permitted one to attain by transperitoneal approach the hypogastric arteries, the presacral nerves, the inferior mesenteric plexus, the periaortic plexus and the lumbar sympathetic chains.

On all the animals, I ligated the hypogastric arteries bilaterally and close to their origin. With the circulation in the pelvis disturbed in this way, I tried by different sympathetic interventions to influence the development of the collateral arterial circulation in the pelvis. To control the results, the sympathetic interruption was always made unilaterally and on the left side. It then became possible to compare under identical technical conditions and in the same animal

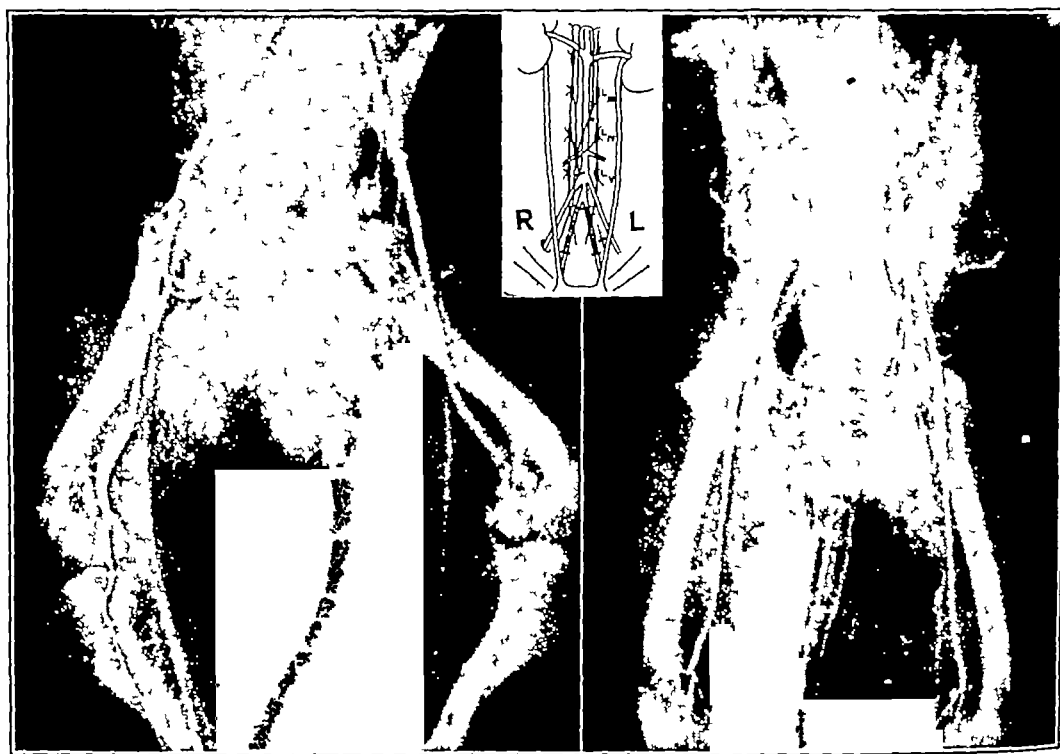


Fig. 3 (experiment 1)—Ligation of the hypogastric arteries and resection of the left presacral nerve. Arteriographic study six days and thirteen days after the operation on the dog. Note the greater vascular tree on the left side, resulting from section of the presacral nerve.

the development of the arterial collateral circulation in the sympathectomized and nonsympathectomized sides.

Sodium iodide was used as the roentgenographic contrast medium for arterial injections when the experiments were completed. Injections were made into the abdominal aorta (with sodium iodide) immediately below the origin of the renal arteries under pressure. Arteriography during the injection gave the image, in the living anesthetized animal, of the arterial circulation in the pelvis and in the posterior extremities.

In order to determine the influence of the abdominal sympathectomies on the arterial collateral circulation in the pelvis and in the lower extremities following

ligation of the hypogastric arteries, I made six series of experiments, progressively increasing the number of sympathetic interventions. These with their results are briefly reviewed.

Series 1—In 19 animals I ligated the hypogastric arteries at the same height, and the left presacral nerve was resected from its origin, close to the posterior mesenteric artery, to its termination in the pelvic plexus. The animals were kept under observation from a few days to several months and then studied during life by the radiographic method (arteriography)

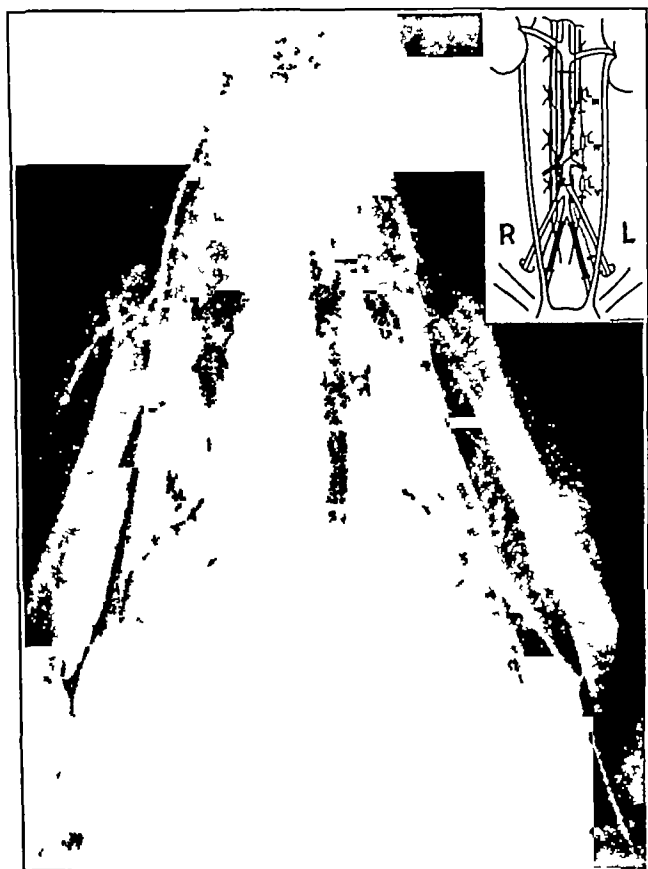


Fig 4 (experiment 2)—Ligation of the hypogastric arteries and sympathectomy of the left hypogastric artery. Arteriographic study twenty-one days after the operation on the dog.

Six days after this experiment, arteriography already revealed larger arterial collateral circulation on the sympathectomized left side, not only in the uterus and annex but also in the pelvic cavity (fig 3). Thirteen days later, the development of the arterial collateral circulation was more advanced. The left half of the pelvic cavity presented a more extensive arterial network than did the opposite side (fig 3). In some

experiments it was observed that resection of the presacral nerve similarly influenced the circulation in the bladder, the arterial network in that half of the organ was richer than in the opposite side. These experiments demonstrated that resection of the presacral nerve induces an increase of the arterial collateral circulation in the corresponding half of the pelvic organs.

Series 2—In another series (4 experiments), after ligation of the hypogastric arteries, the periarterial plexus of the left hypogastric artery was removed. The animals were kept under observation for varying periods after operation. Usually no large collateral circulation in the pelvis was to be noticed on the sympathectomized side (fig. 4).

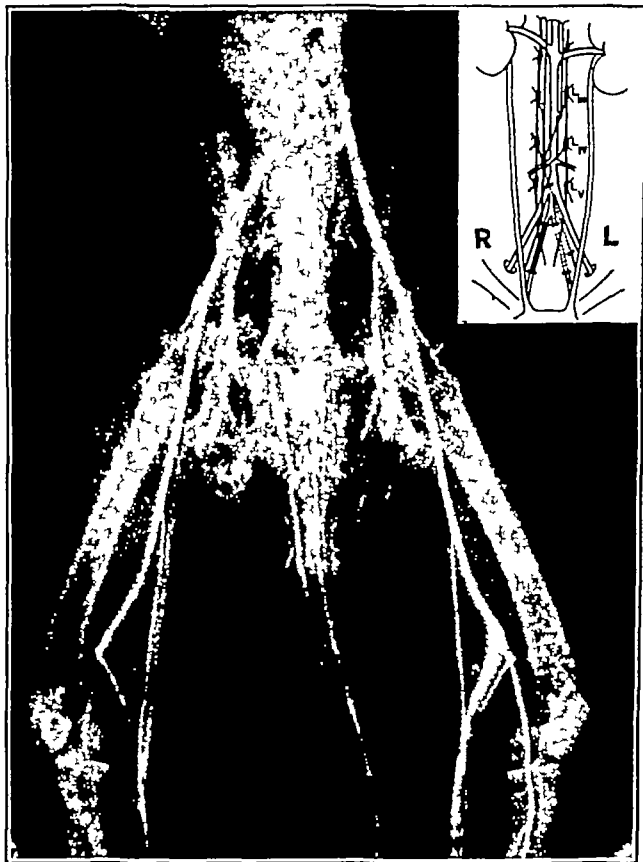


Fig. 5 (experiment 3)—Ligation of the hypogastric arteries followed by resection of the left presacral nerve and section of the left hypogastric artery. Arteriographic study five and a half months after the operation on the dog.

Series 3—Interruption of the vasomotor sympathetic pathways which follow the presacral nerves and of those which follow the adventitia of the left hypogastric artery determines a status of vasodilatation in the corresponding half of the pelvis, this is shown in the increase of

arterial collateral circulation a few days later (4 dogs) A few months after the intervention, this increase in arterial collateral circulation became greater (2 dogs) Development of arterial collateral circulation was manifest not only in the vessels of the viscera but likewise in the wall of the pelvis in that half of the side corresponding to that of the sympathetic intervention (fig 5)

Series 4—In 5 cases in which ligation of the hypogastric arteries had been followed by resection of the left presacral nerve and a lower



Fig 6 (experiment 4) —Ligation of the hypogastric arteries followed by resection of the left presacral nerve and resection of the left fourth lumbar sympathetic ganglion Arteriographic study nine days after the operation on the dog

lumbar sympathectomy of the fourth lumbar ganglion on the same side, an increased arterial collateral circulation was observed in the corresponding side of the pelvis The vasomotor effect was not limited to the pelvic cavity, but extended to the left leg At the level of the thigh and the calf the arterial circulation was greater than in the extremity on the opposite side (fig 6)

Series 5—Resection of the left presacral nerve, with the fourth lumbar sympathetic ganglion and the left perihypogastric sympathectomy, caused an increase in the arterial network not only on the left side of the pelvis but also in the leg of the same side (fig 7). As this was verified for 8 dogs, on examination of the arteriographies of these experiments, I was left with the impression that the increase noted in the arterial collateral circulation following intervention was more pronounced than had been observed in the previous set of experiments.

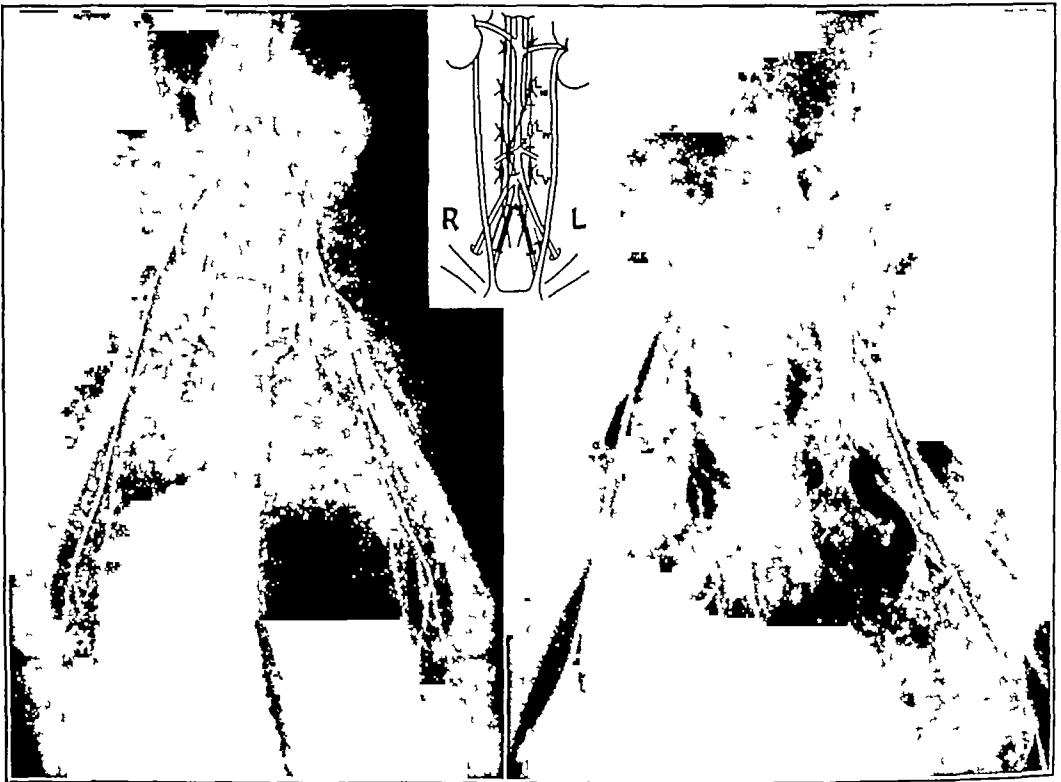


Fig 7 (experiment 5)—Ligation of both hypogastric arteries followed by resection of the left presacral nerve, resection of the left fourth lumbar sympathetic ganglion and sympathectomy of the left hypogastric artery. Arteriographic studies fourteen and twenty days after the operation.

Series 6—Finally, in the last series of experiments (4 dogs), in addition to the resection of the left presacral nerve, resection of the fourth and fifth lumbar ganglions and periaortic sympathectomy were added. There followed a vasomotor effect in these 4 cases which showed in the following days and months an evident increase in arterial collateral circulation at the level of the pelvis and the posterior extremity on the side sympathectomized. It was in these cases that the development of arterial collateral circulation in the pelvis and the posterior extremity

attained the maximum intensity as compared with the previous experiments (fig 8)

INFLUENCE OF ANESTHETIC BLOCK OF THE LUMBAR SYMPATHETIC
CHAIN ON CIRCULATION OF THE GENITAL ORGANS
AND OF THE LOWER EXTREMITIES

The results already mentioned obtained in the experimental investigations performed on animals led me to investigate the circulatory change produced by interruption of the lumbar sympathetic chain in patients with cancer of the cervix uteri. Not only the arterial change in the uterus but also the circulation of the lower extremity on the



Fig 8 (experiment 6)—Ligation of the hypogastric arteries followed by resection of the left presacral nerve, resection of the left fourth and fifth lumbar sympathetic ganglia and periaortic sympathectomy. Arteriogram four months later

same side was studied. These changes in the local blood supply were investigated indirectly through the modification of the local temperature taken at the same time in the uterus, in the fornices of the vagina

and in the lower extremities. This was done with different electrodes of an electric thermometer. Local temperatures were observed before and after the anesthetic block of the lumbar sympathetic chain. For about one hour the temperatures, taken every five minutes, were recorded at the level of the regions where the electrodes were placed.

Several observations were made after anesthetic block of the lumbar sympathetic chain was performed at different levels, in some cases at the level of the first lumbar ganglion, in some at the second, in others at the third and finally at the fourth lumbar ganglion. These observations showed that in all the cases interruption of the lumbar sympathetic chain was followed by an increase in the temperature of the uterus,

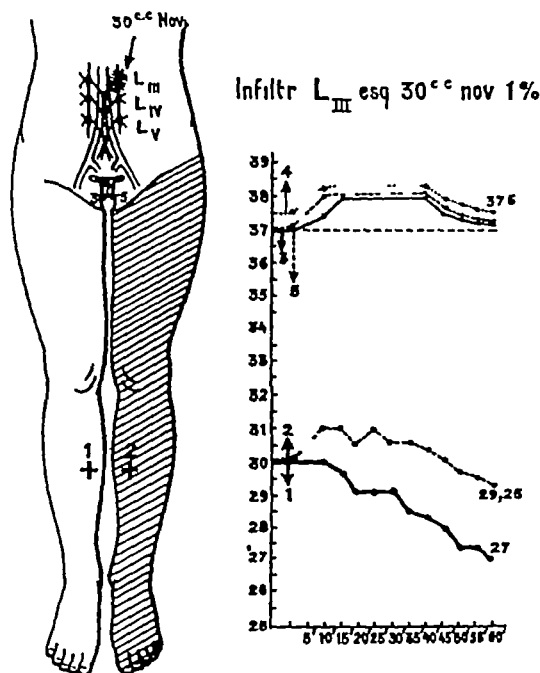


Fig 9—Influence of the anesthetic block of the left third lumbar sympathetic ganglion on the temperature of the uterus, vagina and lower extremity, in a patient with carcinoma of the cervix uteri

of the fornices of the vagina and of the lower extremity on the side of the sympathetic intervention. The 2 cases that follow give an idea of the modification of local temperature produced by unilateral anesthetic block, with procaine hydrochloride, of the second or third lumbar sympathetic ganglions.

CASE 1—A patient with a basal cell carcinoma of the cervix uteri in stage II was given an injection of 30 cc of 1 per cent solution of procaine hydrochloride into the second lumbar ganglion on the left side. Ten minutes after the beginning of anesthesia, the temperature in the uterus had risen from 37°C (98.6°F) to 37.9°C (100.2°F) and in the left fornix to 37.8°C (100°F), in both it rose to 38°C

(100.4 F) after fifteen minutes. In the right fornix, the temperature rose from 37 C (98.6 F) to 37.5 C (99.5 F) in ten minutes. The temperature of the left leg rose from 30 C (86 F) to 31.25 C (88.2 F) in ten minutes, in the lower extremity on the opposite side there was no noticeable increase in temperature.

CASE 2—A patient with a basal cell carcinoma of the cervix uteri in stage I was given an injection into the left third lumbar sympathetic ganglion. The temperature at the level of the orifice of the cervix uteri rose from 37.5 C (99.5 F) to 38 C (100.4 F) and at the level of the left fornix of the vagina from 37 C (98.6 F) to 38 C (100.4 F) (fig 9). In the right fornix of the vagina it rose only to 37.3 C (99.1 F). At the end of fifteen minutes the temperature was 38.2 C (100.7 F) in the cervix uteri and 38 C (100.4 F) in the fornices of the vagina, remaining steady for forty minutes, after which it began to decline. An hour later it was 37.6 C (99.6 F) in the cervix and 37.5 C (99.5 F) in both fornices. In the lower extremity on the side of the anesthetic block the temperature rose in ten minutes from 30 C (86 F) to 31 C (87.8 F). It remained there for twenty-five minutes but began to decline, and at thirty minutes it was 30.5 C (86.9 F).

Examination of all thermal variations verified in this case after anesthetic blocking of the left lumbar sympathetic chain by infiltration of procaine hydrochloride in the left third lumbar ganglion showed that there had followed an immediate rise in temperature at the level of the cervix uteri and in the left fornix of the vagina. The temperature of the right fornix rose to the same height but five minutes later. This hyperthermia of the uterus and the vaginal fornices continued the same for forty minutes and then began to decline. One hour later it was still higher than it had been before the anesthetic block. In the left lower extremity the temperature increased 1 degree (C) in twenty-five minutes, after which it started to drop progressively.

VASOMOTOR INFLUENCE OF THE SYMPATHETIC ABDOMINOPELVIC INNERVATION ON THE BLOOD SUPPLY OF THE UTERUS

The abundance of nerve fibers in the uterine musculature and along the blood vessels has been shown clearly by the more recent investigations of the intrinsic innervation of the uterus (Kuntz¹³). In regard to the vasomotor innervation of the uterus and fallopian tubes, Kuntz stated that the sympathetic supply includes the vasoconstrictor fibers for the female genitalia. The vasodilator fibers appear to be components of the parasympathetic nerves. It is now known that interruption of the vasoconstrictor fibers supplying an organ is followed by dilatation of the blood vessels in that organ, probably by removing the impulses that maintain the tonus of the smooth muscle of the vessels. The resultant vasodilatation also increases the development of collateral circulation, a phenomenon manifest when the main vascular trunks are interrupted.

The aforementioned experiments performed on dogs showed that the unilateral resection of the hypogastric plexus was followed by an

13 Kuntz, A. The Autonomic Nervous System, Philadelphia, Lea & Febiger, 1934.

increase of arterial collateral circulation at the level of the same side of the uterus and the wall of the pelvic cavity. Less evident was the effect produced by sympathectomy of the left hypogastric artery. On the other hand, interruption of the vasomotor pathways of the innervation of the genital organs at the level of the lumbar sympathetic chain plus periaortic sympathectomy produced the maximum increased collateral arterial circulation.

In patients with carcinoma of the cervix uteri, these experimental results are confirmed. Anesthetic block of the lumbar sympathetic chain at the level of the first, the second or the third ganglion provoked an increase in local temperature at the level of the endocervical canal of the uterus and of the fornix of the vagina on the same side as the interruption of the vasomotor sympathetic innervation.

All these facts show that the uterus is innervated by efferent sympathetic vasomotor fibers and that interruption of these sympathetic pathways is followed by vasodilatation, which provokes an increased temperature at the level of the uterus and an increased collateral circulation.

PROBLEM OF RADIOSENSITIVITY AND BLOOD SUPPLY IN CANCER

In the interpretation of the results of radium therapy for cancer of the cervix, one must take into consideration not only the technic of the irradiation but also such factors as the extent of the lesions, the cervicouterine microbial infection, the age of the patient, the histologic type of the cancer and its radiosensitivity.

In the statistics of Simone Laborde,¹⁴ the decrease in the number of cures is shown as the extension of the lesion increases. Thus if the percentage of cured patients in stage I is 66 per cent, it decreases to 48 per cent in stage II and drops to 30 per cent in stage III. The cervicouterine microbial infection not only decreases the local radiosensitivity of the infected neoplasia but can even originate accidents in the course of radium therapy (Simone Laborde). Age is also a factor, it is known that in young women the malignancy and rapidity of evolution of carcinomas of the cervix are more pronounced than in women of advanced age. The morphologic varieties and the histologic types of carcinomas of the cervix behave differently in their relation to irradiation. Simone Laborde¹⁵ says that the vegetating cancers are less malignant and are more quickly modified under the influence of the

14 Laborde, S. Les resultats de la radiotherapie des cancers cervico-utérins du premier degre. Statistique de l'Institut du cancer, Bull. Assoc. franç. p. l'étude du cancer **30** 43, 1942.

15 Laborde, S. Que se pode esperar de radioterapia dos cancros, Arq. de pat. **11** 26, 1939.

radiation than are the infiltrating or ulcerous forms Cutler¹⁶ has stated the strong conviction that the gross character of the lesion, more particularly of its papillary or infiltrating character, may be, in certain circumstances, a more significant guide to radiosensitivity than is the microscopic appearance of the growth And Cathie¹⁷ concluded from his investigations that some of the tumors showing atypical histologic features manifested a typical radiosensitivity, while, on the other hand, in his series of some 5,500 cases there were many atypical responses by histologically similar tumors From these facts, it is obvious that it will not be possible to give a certain forecast of sensitivity of the tumor from the histologic preparations According to Cathie,¹⁷ however, one should indicate as nearly as possible the probabilities of radiosensitivity when reporting on biopsy material

Though it is indeed difficult to estimate the degree of radiosensitivity of various carcinomas of the cervix, a number of attempts have been made to determine the existing relation between the histologic types and the sensitivity of the tumor to irradiation Some authors have already established for carcinomas of the cervix different degrees of radiosensitivity in relation to cellular differentiation The carcinomas with cellular elements of adult type appear to be the most radioresistant, those offering greater sensitivity to radiation are the carcinomas of undifferentiated cells (basal cell and transitional cell) Yet the evaluation of radiosensitivity through the histologic type presents a certain difficulty of practical application in the case of carcinomas of the cervix, since it is not easy to define the histologic types on account of the rarity of pure forms and the variety of morphologic aspects according to the location of the biopsy This means, therefore, that one cannot submit to any schematic formula the radiosensitivity of the neoplasms of the cervix The radiosensitivity of a tumor plays an almost dominant role in the radiotherapy of cancer (Stewart and Farrow¹⁸) The selection of the treatment to be followed depends on the sensitivity of a tumor to irradiation, in some instances this is curative, in others simply palliative However, until the present time there has been no method of determining beforehand with precision whether or not a tumor is sensitive to radiation Therapeutic practice led Stewart and Farrow¹⁸ to the conclusion that the behavior of tumors to radiation is an individual problem

16 Cutler, M The Problem of Radiosensitivity, *J A M A* **103** 1204 (Oct 20) 1934

17 Cathie, J A B Some Histological Tumor Variants and Their Influence upon Radiosensitivity, *Radiology* **32** 425, 1939

18 Stewart, F W, and Farrow, J H The Radiosensitivity of Tumors, in Pack, G T, and Livingston, E M Treatment of Cancer and Allied Diseases, New York, Paul B Hoeber, Inc., 1940, vol 1, p 98

In regard to the radiosensitivity of the tumor cells themselves, Cutler and Buschke³ declared that one can distinguish three forms of radiosensitivity inherent, transient and acquired. Very early Regaud¹⁹ had already demonstrated that the same cell is more radiosensitive during certain active phases of mitosis than during a phase of repose. This observation led to the conclusion that the cellular radiosensitivity decreases as the cell advances in its evolution toward maturity or higher differentiation. According to Cutler and Buschke,³ however, the generally admitted opinion that the degree of cellular differentiation is inversely proportional to the radiosensitivity is not an invariable rule.

As to the acquired radiosensitivity, though it is not known how to account for the increase of inherent radiosensitivity, it is known that it can be decreased by certain external factors. Thus a previous irradiation or an inadequate surgical intervention or yet a disturbance of the normal blood supply of the tissues can interfere with the radiosensitivity of a tumor. Cutler and Buschke³ stated that clinical and experimental observations indicate that its radiosensitivity is decreased when the blood supply of a tissue is reduced. This reasoning has suggested an effort to attain a normal blood irrigation in the treatment of cancer by irradiation. Investigations have already been made to increase the blood supply and the oxygenation of a tumor, before or during irradiation, by diathermy and the injection of oxidizing substances into the tumor.

It is now known that the radioresistance of a tumor may increase when the irradiation is distributed over a long period or is applied repeatedly. Such a fact would probably result from alterations in the neoplastic cells and from the modification (fibrosis and decrease of vascularization) that takes place in vascularity of the connective tissue in and about the tumor. Cutler and Buschke, therefore, stated the belief that the radiosensitivity of a tumor is determined as much by the environment of the tumor as by its histologic structure. According to Warren,²⁰ the regression of an irradiated tumor is dependent on changes in the supporting stroma and both the blood vessels and the connective tissue as well as on the destruction of tumor cells. Lenz and Haagensen²¹ stated the belief that the resistance of the tissues to irradiation is greatly influenced by their nutrition and vascularization. They pointed out that the vasodilatation following the application of heat or of irritating medicaments increases the radiosensitivity of the skin, on the contrary, it decreases the radiosensitivity if the nutrition or the local blood supply is poor.

19 Regaud, cited by Cutler and Buschke³

20 Warren, S. The Radiosensitivity of Tumors, *Am J Roentgenol* **45** 641, 1941

21 Lenz, M., and Haagensen, C. D. The Treatment of Cancer, in *Nelson's Loose-Leaf Living Surgery*, New York, Thos Nelson & Sons, 1927, vol 2, p 135

In the irradiation of tumors one can still observe the phenomenon of radioimmunization, which, according to Simone Laborde,¹⁵ represents one of the difficulties in the radiotherapy of cancers. Thus a malignant tumor, after it has reacted favorably to the first irradiation, can become immune to subsequent irradiations and is not influenced by them. Simone Laborde¹⁵ and Roussy and Leroux²² attributed, in part, the phenomenon of radiovaccination to the state of the vasculoconnective stroma modified by previous irradiations. Cutler and Buschke⁸ stated that an acquired radioresistance may be due in part to inadequate previous radiologic or surgical treatment or to any interference with the normal blood supply of the tissues. They cite as an example a carcinoma developing in an operative scar or burn—i.e., in a devascularized skin—its radiosensitivity being much less than that observed in a carcinoma implanted in the normal skin.

On the other hand, the changes determined by the irradiation of carcinomas of the cervix have been studied during the course of treatment by repeated biopsies. It has been shown that during the period of from twenty-four to thirty-six hours after the beginning of irradiation there is usually a decrease in the number of mitoses (Lenz and Haagensen²¹), this is followed by a phase of increase in the number of mitoses, which are largely atypical. This phase of active degeneration shows a greater or a less duration according to the type of the tumor and the intensity of the radiation. Ewing and Pullinger²³ have pointed out that the irradiation is effective largely through the vascular disturbance that it creates.

It is now known that the irradiation of a tumor is followed by immediate and slow alterations in the supporting vasculoconnective tissue by sclerosis. This fibrosclerosis, appearing before the destruction of the malignant cells, can reduce the blood supply of the region to the extent of making sterilization impossible (Cutler and Bushke⁸). The decrease in the vascularity of the connective tissue after irradiation is due to sclerosis of the internal and muscular layers and, subsequently, obliteration of the vessels. This leads to atrophy and at the same time creates favorable conditions for infection. The idea of reducing sclerosis from irradiation has already been put into practice. In carcinomas of the cervix submitted to irradiation, Gentil²⁴ and Guedes²⁵ tried the complementary treatment by gynecologic diathermy. This therapeutic

22 Roussy and Leroux, cited by Laborde¹⁵

23 Ewing and Pullinger, cited by Lenz and Haagensen²¹

24 Gentil, F. La diathermie gynécologique, moyen auxiliaire précieux de la curietherapie utero-vaginale, *Arq de pat* 2 300, 1930

25 Guedes, B. La diathermie gynécologique, moyen auxiliaire de la curietherapie uterovaginale, *Cong internat de physiol*, 1930

innovation is at the present time followed at the Portuguese Institute of Oncology, and the results obtained have encouraged its continuation

From an analysis of the facts now known about the radiosensitivity of tumors, radioimmunization, the mechanism of the cellular action of irradiation and the changes in the vasculoconnective stroma of cancer, it would appear that the vascular factor plays an important role in the results from irradiation

Quick,²⁶ in 1942, analyzing the present state of radium therapy, discussed the treatment of carcinoma of the cervix and corpus uteri. He suggested that further investigation is necessary to discover a method of preirradiation therapy that will render the tumor-bearing area more sensitive to irradiation. Quick pointed out that in the search for ways and means of rendering tumor tissues more sensitive to irradiation and normal tissues more resistant one must not lose sight of the biophysiological factor. He stated that it has long been known that an optimum response to a given amount of radiation does not occur in the presence of secondary anemia. Daland²⁷ agreed that when the circulation of the region is poor the harmful effect of irradiation is greater. The circulation after radium therapy becomes poorer in the area treated, and closure of vessels to that region will result in gangrene of the area.

According to Cutler¹⁸ there is considerable evidence to indicate that tumors pass through alternating periods of radioresistance and radiosensitivity. The radiosensitivity of a cell is not constant. When the metabolic rate is high, as in rapidly growing tumors, radiosensitivity is high (Mottram²⁸). That changes in metabolism affect response to irradiation seems to be demonstrated by the experiments of Packard²⁹, he showed that lowering the metabolic rate by reducing the temperature lowered the susceptibility to irradiation.

On animals Jolly³⁰ performed ligation of the common iliac artery of one side. Then, for one or two hours he irradiated simultaneously the popliteal lymph nodes of the two lower extremities. By histologic study he verified in two, three or four hours after the end of the irradiation

26 Quick, D. The Present States of Radium Therapy, *Am J Roentgenol* **47** 607, 1942, Radium in Present Day Therapeutics, New York State J. Med. **44** 981, 1944

27 Daland, E. M. Radiation Damage to Tissue and Its Repair, *Surg, Gynec & Obst.* **72** 372, 1941

28 Mottram, J. C. On the Spacing of Radiation According to Variation in Radio-Sensitivity, *Brit. J. Radiol* **9** 824, 1936

29 Packard, cited by Cutler¹⁸

30 Jolly, J. Action des rayons x sur les cellules. Diminution de la réaction d'un organe sensible par la ligature des arteres afferentes, *Compt. rend. Soc. de biol.* **91** 532, 1924

tion that the alterations were less pronounced in the lymph nodes with diminished arterial blood supply. This would probably be explained by the qualitative and quantitative modification of cellular exchanges. A similar effect was demonstrated by Ferroux, Jolly and Lacassagne³¹ by ligating one ovarian pedicle and irradiating both ovaries simultaneously. They reported that the effects of irradiation were minimal in the ovary with the lesser blood supply. These experiments demonstrate that the intervention of the supply of blood to the organs exposed to irradiation is followed by increased radioresistance.

In my investigations concerning the influence of the sympathetic innervation in the treatment of pain in inoperable cancers, I was led to study the role of the increased blood supply of the tumor resulting from intervention of the vasomotor innervation in relation to increased radiosensitivity. According to Cutler,¹⁶ the ultimate criterion and only absolute test of the radiosensitivity of the tumor is its clinical behavior. And since the response of a tumor to irradiation, the therapeutic test remains the most accurate and certain clue to its radiosensitivity, I have investigated in patients the influence of hyperemia produced by sympathetic block in radium therapy of carcinoma of the cervix uteri.

TECHNIC USED IN INTERRUPTION OF INNERVATION OF THE UTERUS BY REPEATED ANESTHETIC BLOCKS OF THE LUMBAR SYMPATHETIC CHAIN

The uterus derives its nerve supply mainly from the anterior border of the large portion of the pelvic plexus (Hovelacque³²). These nervous filaments constitute the uterine plexus, which is connected with the vaginal plexus. In woman, the pelvic plexus, which is similar to that in man, arises in the bifurcation of the hypogastric plexus. Both the right and the left pelvic plexuses descend into the pelvic cavity, following a divergent course, to round the posterior and lateral surfaces of the rectum afterward, then they continue forward without, however, attaining the lateral border of the uterus. The hypogastric plexus represents the continuation of the intermesenteric plexus, which receives its principal roots from the lumbar sympathetic chains.

It is at the level of the lumbar sympathetic chain and its efferent branches and roots of the intermesenteric and of the hypogastric plexuses, that one can intercept either the afferent (sensory) or the efferent (vasomotor) pathways, which, following the hypogastric plexus and the hypogastric arteries, innervate the uterus. Anesthesia of the lumbar sympathetic chain and of the roots of the hypogastric plexus interrupts

31 Ferroux, Jolly and Lacassagne, cited by Cutler and Buschke.³

32 Hovelacque, A. Anatomie des nerfs craniens et rachidiens et du système grand sympathique, chez l'homme, Paris, G. Doin & Cie 1927.

the pathways of painful sensations, arising in the uterus and running along the hypogastric plexuses to reach the lumbar sympathetic chain and the spinal cord, through the eleventh and twelfth thoracic nerves. This effect is shown during the treatment with intrauterine radium by a decrease of local painful sensibility. From such observations I had the impression that the patients tolerated radium better and complained less than during the period of treatment when repeated anesthetic blocks of the lumbar sympathetic chain were performed.

In the series of investigations, the results of which this work presents, I made anesthetic blocks on the right and on the left every day during the period of radium application. With 30 cc of 1 per cent procaine hydrochloride solution, the lumbar sympathetic chain at the level of the first, second or third lumbar vertebra was infiltrated in each patient, and, in order that the punctures might be better tolerated, they were always made at different points.

The technic of anesthetic block of the lumbar sympathetic chain is easy and has been described by several authors (Lundy,³³ Leriche,³⁴ Ochsner and De Bakey³⁵). In these investigations I have employed a similar technic but with modifications that experience advised. The patient is placed in a sitting or a lateral recumbent position with the dorsum bent forward. Then the outlines of the spinous processes of the last rib, the transverse processes of the lumbar vertebrae and the iliac crests are marked. From these landmarks, which determine the site of the lumbar sympathetic ganglions, the level of the desired block can be determined.

Then at a point lying from 2.5 to 5 cm from the sagittal plane of the spinal processes, one introduces a needle of 10 to 12 cm in length. When the needle is introduced 2.5 cm from the middle line, it must be passed parallel to the sagittal plane between the two transverse processes, so that on reaching the body of the vertebra it will follow the border of the latter. If, however, the needle is introduced laterally at a distance greater than 2.5 cm, it should be inclined toward the sagittal plane, to permit its just grazing the lateral border of the body of the vertebra. As soon as the point of the needle touches the body of the vertebra or a transverse process, it is withdrawn a little and inclined more obliquely so that it will continue in its deeper progression to graze the lateral border of the body of the vertebra. It is pressed 1 or 2 cm farther, and then one has the feeling of having penetrated

33 Lundy, J. S. *Clinical Anesthesia. A Manual of Clinical Anesthesiology*, Philadelphia, W. B. Saunders Company, 1944, p. 159.

34 Leriche, R., and Fontaine, R. *Technic and Indications for Procaine Hydrochloride Infiltration of Lumbar Sympathetic*, *Presse méd.* **42**: 1843, 1934.

35 Ochsner, A., and De Bakey, M. *Treatment of Thrombophlebitis by Novocaine Block of Sympathetics. Technique of Injection*, *Surgery* **5**: 491, 1939.

into a free space, with less resistance. The point of the needle is then in front of the anterior surface of the psoas muscle, which covers the sympathetic chain. Aspiration is made in order to be sure that there is no bleeding, then slowly 30 cc of 1 per cent procaine hydrochloride solution without epinephrine is injected. In this way it is possible to obtain the physiologic interruption of the sympathetic chain at the level at which the anesthetic infiltration is made.

This procedure is repeated at the level of the first, second or third lumbar sympathetic ganglion, depending on the desired anesthetic block. The anesthetic, diffusing in front of the psoas muscle close to the vertebral body, anesthetizes not only the sympathetic chain but also the roots of the hypogastric plexus. The resulting physiologic block not only reduces the painful sensibility of the uterus but also increases its blood supply. Probably a similar result may be obtained by blocking the lumbar sympathetic chain with alcohol or long-acting anesthetic drugs.

RESULTS OBTAINED IN TREATMENT OF CARCINOMA OF THE CERVIX UTERI BY RADIUM THERAPY ALONE OR BY RADIUM THERAPY ASSOCIATED WITH HYPEREMIA, IMMEDIATE RESULTS

For one year I studied all patients with carcinoma of the cervix uteri who were treated at the Portuguese Institute of Oncology. About half of them were submitted to routine treatment by radium therapy, preceded and followed by roentgen ray therapy, with gynecologic diathermy added. In other patients, during the period of application of radium, a state of hyperemia at the level of the uterus was induced by repeated daily lumbar blocks with procaine hydrochloride. There was no special selection of patients in either series, the treatment was maintained for six months in all cases. The results, therefore, are from different stages (I, II and III), from patients of different ages and from tumors of diverse morphologic types.

The cases are grouped as (1) basal cell carcinomas and (2) adenocarcinomas of the cervix. In interpreting the results for each of these groups, the stage of the neoplasia, the patient's age, the dose of radium and the technic of irradiation were considered. The results are restricted to a period of a year and a half after the treatment.

The technic of irradiation used for these patients was the one routinely used at the Portuguese Institute of Oncology: roentgen rays, in doses of 2,400 r, preceding the use of radium in the uterus and vagina in the habitual dose of 50 mg, and roentgen rays in doses of 16,600 r following the use of radium and gynecologic diathermy.

Repeated gynecologic examinations were made of these patients in order to evaluate the evolution of the lesions. The examinations were continued at variable intervals during the months that followed.

I Series of Patients Routinely Treated Without Sympathetic Block

—1 The first group of patients with basal cell carcinomas comprises 34. Six patients with carcinoma of the cervix in stage I were of ages varying from 23 to 56 years. The doses of radium applied to the uterus and vagina varied from 25 to 50 mg. The results in these 6 patients were as follows. The cervix healed in 4 patients at the end of the treatment and remained well for periods up to fourteen months, 1 was worse at the end of the treatment, and the other had a recurrence of the lesion six months later.

2 In 8 patients between the ages of 37 and 63, the carcinoma of the cervix was of stage I or II, the doses of radium varied between 25 and 50 mg. In 4 cases the cervix was healed, and nothing was heard afterward of recurrence. In 3 of the others the neoplasia recurred, and in 1 case the lesion did not improve.

3 In 18 patients with basal cell carcinoma of the cervix in stage II, the ages ranged from 29 to 68. The doses of radium applied were from 25 to 50 mg. In only 8 of these patients was there healing without recurrence within the period of observation. In 4 patients the lesions grew worse, and 1 of these died in four months. Of the remaining 5, frank recurrence was shown in 2 and clinical signs that made recurrence probable in 3.

4 Finally, 2 patients, aged 59 and 66 years, had basal cell carcinoma of the cervix uteri in stage III. In 1 case the dose was 27 mg. and in the other 25 mg. The former showed an unimproved lesion at the end of the treatment, the second died.

II Series of Patients Given Routine Treatment Plus Sympathetic Blocks—In the second series of patients with basal cell carcinoma of the cervix uteri (28), I made repeated daily anesthetic blocks of the uterine innervation during the period of application of radium with procaine hydrochloride infiltration of the lumbar sympathetic chain on both sides. In this way it proved possible not only to reduce the uterine pain but also to create a state of hyperemia at the level of the organs of the pelvic cavity. The following results were obtained in this series of patients with basal cell carcinoma.

1 In 11 patients with carcinoma of the cervix uteri in stage I, the ages were from 31 to 61 years and the doses of radium employed ranged between 27 and 50 mg. Of these 11 patients, the cervix healed in 10 and remained well during the period of observation. In only 1 patient did the lesion recur, four months later.

2 In 1 patient, aged 52 years, the carcinoma of the cervix was in stage I-II. Radium was applied to the vagina and uterus in a dose of 50 mg. The cervix healed, but the tumor recurred locally four months later.

3 In the 12 patients with carcinoma of the cervix uteri in stage II, the ages ranged from 35 to 59 years. The doses of radium applied varied between 27 and 60 mg. In 6 the cervix healed and was in good condition after the treatment, in 3 the cancer recurred three to four months after the treatment, and in 2 the lesion grew worse. In 1 the lesion of the cervix healed, but there were metastases to the bones.

4 In 1 patient, aged 68, with carcinoma of the cervix uteri in stage III, to whom a dose of radium of 50 mg. was applied to the uterus and vagina the lesion healed, but it recurred two months later.

5 In 3 patients with carcinoma of the cervix and body of the uterus, whose ages ranged between 49 and 54 years, doses of radium of 27 to 50 mg. were applied. The first of these patients died one month

TABLE 1—Results in Treatment of Carcinoma of the Cervix Uteri

Stage	Cases	Improvement	No Improvement	Recurrence	Death	Metastasis to Bone
Treatment with Radium Alone (34 Cases)						
I	6	4	1	1		
I II	8	4	1	3		
II	18	8	4	6	1	
III	2		1		1	
Treatment with Radium and Repeated Anesthetic Blocks of the Lumbar Sympathetic Chain (28 Cases)						
I	11	10		1		
I II	1			1		
II	12	6	2	3		1
III	1			1		
Carcinoma of cervix and body of uterus	3	2			1	

after treatment, in the 2 others the cervix healed and kept well eight and twelve months respectively after the treatment.

I have also attempted to analyze the results of the treatment in relation to the neoplastic stage in this series of observations of basal cell carcinoma of the cervix uteri. Table 1 illustrates the results obtained in these cases (1) with radium only and (2) with lumbar sympathetic blocks.

An analysis of the results obtained in the series of 34 patients with basal cell carcinomas of the cervix uteri treated by radium and following the orientation routinely adopted in the Portuguese Institute of Oncology is given in table 2. During a period of observation lasting for one and a half years, the results were as follows: improved 47 per cent, unimproved 20 per cent, recurrence 26 per cent and died 5 per cent.

Of the 28 patients given radium treatment associated with hyperemia provoked by daily anesthetic blocks of the lumbar sympathetic chain induced by procaine hydrochloride, 60 per cent improved, 7 per cent

were unimproved, 25 per cent had recurrence, 3 per cent had metastasis to the bone and 3 per cent died during the period of observation

Besides the 62 patients with basal cell carcinomas of the cervix uteri, there were 5 patients with adenocarcinomas of the cervix uteri. Four of these patients were submitted to the routine treatment by radium, preceded and followed by roentgen ray therapy and completed with gynecologic diathermy. In only 1 of these patients were the lumbar injections of procaine hydrochloride added. These patients were between 40 and 65 years old, and the disease was in stage II. The doses of radium applied were of 50 mg, except in 1 case with an application of 30 mg. The first patient of this series died sixteen months after the treatment, without improvement in the ulceration. The cancer recurred in the second, the third patient was worse after the treatment and died five months later, the result of the fourth case is not known, the fifth patient, aged 53, with an adenocarcinoma of the cervix

TABLE 2—*Results in Treatment of Carcinoma of the Cervix Uteri*

Treatment with	Improve- ment, %	No Im- provement, %	Recurrence, %	Metastasis to Bone %	Death, %
Radium, roentgen rays before and after use of radium and gynecologic diathermy (84 cases)	47	20	26		5
Radium, roentgen rays before and after use of radium, gynecologic diathermy and repeated anesthetic blocks of the lumbar sympathetic chain (28 cases)	60	7	25	3	3

uteri in stage I-II, was treated by daily lumbar sympathetic blocks, vaginal and uterine radium was applied in a dose of 50 mg. The cervix healed and was well during the period of observation lasting four months.

Analysis of all the results within the short time of one and a half years after treatment showed that in basal cell carcinomas as well as in adenocarcinoma of the cervix uteri, the percentage of cases to show healing of the cervix was higher in the series in which daily repeated anesthetic blocking of the lumbar sympathetic chain were added to the routine radium therapy.

SUMMARY AND CONCLUSIONS

1 The investigations of others suggested that the radiosensitivity of a cancer may be favorably influenced by increasing the blood supply in the tumor during the period of irradiation. This led to this investigation in carcinoma of the cervix uteri to determine whether the interruption of the sympathetic innervation by anesthetic block or by sympathectomy would, in addition to reducing the pain, also increase

the blood supply to that region and be useful in the irradiation of the growth. Both experimental and clinical data are presented.

2 The interruption of the extrinsic sympathetic innervation of the uterus at the level of the lumbar sympathetic chain (first, second and third lumbar ganglions) and of the roots of the hypogastric plexus, besides reducing uterine pain through the physiologic block of the afferent painful pathways, also caused hyperemia of the uterus by blocking the efferent vasomotor sympathetic pathways of this organ.

3 In different types of abdominopelvic sympathectomies in dogs, such as resection of the presacral nerve, lumbar sympathectomy and periaortic sympathectomy, an increased arterial circulation in the organs of the pelvic cavity resulted. The higher the abdominopelvic sympathectomy the greater was this increase in collateral circulation. In the cases of lumbar sympathectomy, an increase of arterial circulation was also observed in the lower extremity on the same side.

4 In the treatment of basal cell carcinomas and adenocarcinomas of the cervix uteri, the application of radium associated with hyperemia of the uterus obtained by repeated lumbar anesthetic blocks induced by procaine hydrochloride, in the first, second and third lumbar ganglions showed that the immediate results, in observation up to a year and a half, presented a greater percentage of healings (60 per cent) of the cancerous lesions in the cervix uteri than in cases in which radium alone was applied (47 per cent). The total series includes 62 cases.

5 The results in this small number of cases do not permit definite conclusions, but they suggest that the effects of radium are greater when the circulation to the uterus is increased by a block of the lumbar sympathetic chain. This procedure is also helpful in that the uterine pain is relieved.

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CUTIS GRAFT IN SURGERY

A Review of Results Obtained, with Comments on Indications and Technic
and Report of Cases

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MY COLLEAGUES and I have continued to explore, from time to time, the possibilities of the cutis graft from a theoretic as well as from a practical standpoint. Certainly the field of its usefulness is wide. We have kept in mind the substance of the observations made by various surgeons concerning the special merits of cutis as repair material, such as its pronounced tensile strength and freedom from the tendency to split, the lack of which has been an unfortunate characteristic of fascia lata when subjected to lateral strain.¹ Cutis vascularizes quickly, takes easily and well and is gradually transformed into fibrous tissue. We have made use of cutis tissue whenever and wherever we would have used fascia lata in the past and, we feel, with superior results.²

An extended review of our cases has been made through the medium of patients returning for check-up and by correspondence with the patient's physician and with the patient. The results obtained have been generally gratifying and the failures few, the latter, for the most part, apparently having been due to defects in technic.

TECHNIC

Before the application of cutis grafts, our patients have had, on the day previous to operation, preparation with soap and water followed

1 Cannaday, J. E. The Use of Cutis Graft in Repair of Certain Types of Incisional Herniae and Other Conditions, *Ann Surg* **115** 775-781 (May) 1942, Some of the Uses of Cutis Graft in Surgery, *Am J Surg* **59** 409-419 (Feb) 1943, Additional Report on Some of the Uses of Cutis Graft Material in Reparative Surgery, *ibid* **67** 382-390 (Feb) 1945. Ogilvie, W. H., in Maingot, R. *Post-Graduate Surgery*, New York, D. Appleton-Century Company, Inc., 1937, vol. 3.

2 Rehn, E. Das kutane und subkutane Bindegewebe als plastisches Material, *München med Wchnschr* **61** 118-120, 1914. Rehn, E., and Miyauchi. Das cutane und subcutane Bindegewebe in veränderter Funktion. Eine experimentelle und klinische Transplantationsstudie, *Arch f klin Chir* **105** 1-46, 1914. Rehn, E. Ueber die funktionelle Anpassung des Bindegewebes im chirurgischen Geschehen, *Verhandl d anat Gesellsch* **40** 133-152, 1931, in Lexer, E. *Die freien Trans-*

by alcohol and a sterile dressing. Shortly before operation an iodine-alcohol technic is carried out.

Our present technic of cutting a cutis graft is as follows. After a thin epidermal layer has been shaved away and the area needed outlined with a scalpel, the cutis edge is picked up at one end with two or three Allis forceps and is removed by undercutting with a short, curved pair of scissors. Approximately not more than 1 mm thickness of fatty tissue is allowed to remain on the under surface of the graft.

When a strip of cutis is secured for suspension of the cervix, thick cutis, such as can be obtained from the anteroexternal surface of the thigh, has definite advantages. For this purpose, the strip should be cut sufficiently wide (about 1 or $1\frac{1}{4}$ inches [2.5 or 3 cm]), as cutis narrows greatly when put on longitudinal stretch.

In the repair of inguinal hernia we have for the most part followed the technic of Halsted. In case the structures are poor and a cutis graft reinforcement seems to be indicated, the graft is usually sutured in position under the aponeurosis of the external oblique muscle.

When cutis is used as suture material, our experience indicates that it can be handled with a medium-curved hemostat as satisfactorily as or more so than with any fascia needle that we have seen.

When the aponeuroses are sutured to the placement of the graft, sutures of adequate strength should be used, usually of cotton thread, sizes 15 to 30, however, stainless steel wire or silk is satisfactory. When the graft is fixed on firm tension, no. 30 sutures, spaced not more than $\frac{1}{4}$ inch (0.6 cm) apart, are used. All sutures are interrupted, all knots are tied triple throw style. When cutis is used for reinforcement purposes, the subcutaneous fat should always be carefully sutured down to and over the cutis graft so as to obliterate dead space in the incision. No. 70 or 80 cotton thread is suitable for this.

When the operative incision is closed, the skin edges can be best brought together with vertical mattress sutures. After closure of the wound, a pressure dressing of mechanic's waste is applied. This is usually left in place for ten days or longer.

By use of the removed epidermal layer as a split thickness graft to cover areas from which a cutis graft has been removed, the end results in the donor area are more satisfactory from the cosmetic viewpoint than in the cases in which the skin edges are brought together by undercutting and the use of tension sutures.

Pronounced sudden increase in abdominal constriction resulting from a radical operation for the cure of a large hernia in middle-aged

or elderly patients is not without danger³ Such patients can be accustomed to increased intra-abdominal tension by the comparatively simple expedient of partial suspension of the abdominal portion of the patient's trunk in a sling for several days prior to operation

SURGICAL APPLICATIONS

Stage Operations—In cases of strangulated hernia, the patient's condition may be such that a stage operation is necessary For instance, the strangulation may be released and the operative incision closed, sufficient time being allowed for the general condition of the patient to improve before repair of the hernia is undertaken

Suspension of Uterine Cervix by Cutis Strip—In some cases suspension of the cervix may be made by carrying a strip of cutis through a tunnel made through the periosteal attachments of the rectus muscles At other times this tunnel is made underneath the periosteum of the tuberculum pubis However, there are still other cases in which it may seem more feasible to make the tunnel a little more lateral and to carry it under Cooper's ligament and a portion of Gimbernat's ligament near their attachment in the anterior pubic region

We had formerly, at times, suspended the cervix from the posterior aponeurosis of the rectus muscles near their point of attachment to the pubic arch However, we have had 2 cases of recurrence of prolapse following this type of procedure We have had the opportunity of reoperating on both patients The apparent reason for these recurrences of cervical prolapse was that the anchoring strip of cutis had gradually pulled away from its insertion in the sheath of the posterior rectus muscle

Ligation of Large Blood Vessels—Morton and Scott⁴ observed that any ligation in continuity of a large artery will be frequently followed by a gradual cutting through of the ligature Elkin,⁵ Gage⁶ and others have found fascia to be unsatisfactory for the ligation of large arteries They stated that bands of fascia frequently give way and that cotton tape at times cuts through However, Beck⁷ reported the apparently successful use of fascia to reenforce the walls of an aneurysm

3 Babcock, W W Principles and Practice of Surgery, Philadelphia, Lea & Febiger, 1944, p 85 Thorek, M Modern Surgical Technic, Philadelphia, J B Lippincott Company, 1938, vol. 3, p 1707

4 Morton, J J, and Scott, W J M Ligation of the Abdominal Aorta for Aneurysm Complicated by Rupture into Retroperitoneal Space, *Ann Surg* **119** 457-467 (March) 1944

5 Elkin, D C Aneurysm of the Abdominal Aorta Treatment by Ligation, *Ann Surg* **112** 895-906 (July) 1940

6 Gage, M Personal communication to the author

Since it has been noted by a number of surgeons that when fascia has been used for the purpose of ligating the aorta it has failed to hold and that cotton tape and rubber bands have at times cut through the wall of that vessel, causing fatal hemorrhage, it seems obvious that a more suitable material is indicated. In view of our satisfactory experience with cutis as material for stage ligation of the common carotid artery, it would seem that cutis may prove to be the material of choice in such cases. The aorta could be reenforced with a wide band of cutis, after this a ligature strip of cutis could be passed twice around the reenforcing layer, drawn tightly enough to cut off the flow of blood wholly or in part and then firmly anchored with interrupted U sutures.

A Suggestion in Regard to Chronic Recurring Dislocation of the Shoulder—It has been observed that after the Nicola operation of transplanting the long head of the biceps muscle for the relief of chronic, recurrent dislocation of the shoulder this structure practically disappears from the joint within the course of a few months. In view of this fact, it is believed that cutis graft support for the arm would be more likely to offer permanent relief. It is also felt that if cutis were used in accordance with the Henderson type of operation, which does not invade the joint to an appreciable extent, the prospects for a permanent cure would be good.

REPORT OF CASES

CASE 1—J F, a white man aged 59, was admitted to the Charleston General Hospital Aug 17, 1942. Examination showed a direct inguinal hernia, twice recurrent after previous operative repair. The patient underwent a third repair operation on August 19. A direct sac, of moderate size, was found. The structures about the opening were definitely of poor quality. After a repair had been made in accordance with the McVay technic, the area was reenforced with a cutis graft. A recurrence of this hernia developed about two years later.

CASE 2—Mrs D G, a white woman aged 50, was admitted to the Charleston General Hospital Feb 16, 1945. Her height was 5 feet (152 cm) and her weight 255 pounds (115.6 Kg). This patient was certain that she had had a right upper abdominal incisional hernia recurrent for the third time following a cholecystectomy. The exact location of this hernia was not apparent, but the patient was keenly aware of its presence. She even thought that she might have another hernia lower in the abdomen.

Operation—Operation was performed on February 22 by Dr R. E. Pence and me. We felt that it would be necessary to reopen the abdomen in order definitely to locate the hernia or hernias of which she complained. Accordingly, an incision was made in the line of a previous right upper abdominal incision. Through this opening, the examining fingers were passed. Only one small hernial opening, about 1¾ inches (6.9 cm) medial to the exploratory incision, was found.

7 Beck, C S. Operation for Aneurysm of the Heart, *Ann Surg* 120 34-40 (July) 1944.

The sac contained an adherent knuckle of small bowel, which explained the occasional cramping sensation experienced by the patient. After a seemingly adequate repair of the hernia had been made and the peritoneal and aponeurotic structures of the exploratory opening had been closed, the two exposed areas were firmly reenforced with a cutis transplant of appropriate size, the remaining layers of the incision being closed in the usual manner. The patient had a normal convalescence. However, when the pressure dressing was removed, on the tenth postoperative day, two small, reddened patches of skin in the operative area were noted. The impression at this time was that of an apparent circumscribed local cellulitis. Penicillin was administered intramuscularly for a few days, after which the inflammatory areas rapidly disappeared.

CASE 3—R E T, a white man aged 44, was admitted to the Charleston General Hospital March 6, 1945. His height was 6 feet 1½ inches (186 cm)

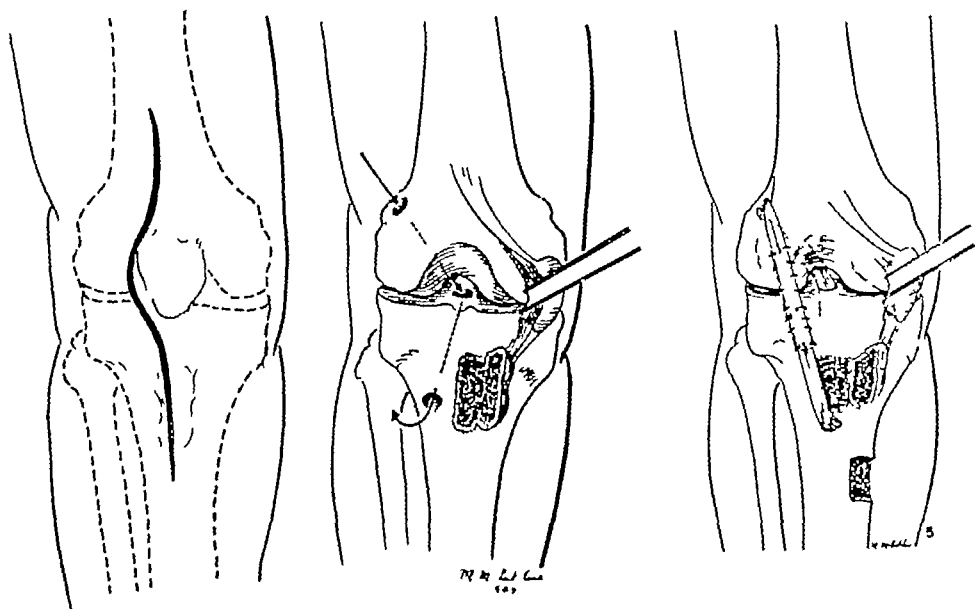


Fig 1—Repair of crucial ligaments of the knee

and his weight 240 pounds (108.8 Kg). He gave a history of a thrice recurrent incisional hernia in the right side of the upper part of the abdomen following a cholecystectomy. Each of the three subsequent operations for repair had been followed by recurrence of the hernia, which bulged to a pronounced degree and extended practically from the costal border to the inguinal ring. The patient stated that whenever he was on his feet the hernial area was the seat of an almost continuous dull, aching pain.

Operation—The patient was operated on March 6 by Dr R E Pence and me. When the hernial sac was exposed, it was noted that in the central area the defect in the aponeurosis was approximately 3½ inches (8.8 cm) in width and also that the bulge extended down to and apparently was continuous with what was evidently an early direct right inguinal hernia. The sac was closed by infolding, multiple interrupted sutures of no 40 cotton thread being used for this purpose. The aponeurotic structures were approximated with sutures of no 15 cotton thread tied with triple throw knots. No attempt was made to deal

with the inguinal hernia because of the fact that the operation would have been unnecessarily prolonged and also by reason of the fact that the inguinal part of the hernia so far had not caused pain. The hernial repair was firmly reenforced with a cutis graft (which, when cut and sutured in place on tension, was at least $8\frac{1}{2}$ inches [21.5 cm] long by $2\frac{1}{2}$ inches [6 cm] wide) taken from the antero-external surface of the right thigh. The interrupted anchoring sutures of no. 40 cotton thread were spaced about $\frac{3}{4}$ inch apart and tied twice firmly in the usual double throw knot. The patient, being under continuous spinal anesthesia, gave a slight cough at this stage of the operation. Simultaneously, it seemed, at least twelve of the fixation sutures slipped untied, as if by magic. All the graft fixation sutures were then replaced by no. 30 cotton thread tied with triple throw knots instead of double.

This patient was allowed to get out of bed each day subsequent to the operation. A few days following the operation the patient had a slight accession of fever. Roentgenologic examination showed evidence of a moderate amount of bronchitis. This cleared up in a few days.

The pressure dressing was removed on the tenth postoperative day to allow for the removal of the vertical mattress skin sutures. Following this, there was a small amount of serous leakage from the lower angle of the wound. This drainage persisted for about six months, gradually diminishing in amount, after which time the operative incision was apparently entirely healed.

Before the superficial sinus finally closed, it was noted that a small area (about $\frac{1}{4}$ inch) of the tip of one corner of the cutis graft was visible. However, it was firmly fixed in the tissues and was apparently well covered with epidermis.

Follow-up—Recent examination with the patient standing shows the repaired area to be firm and without any sign of a bulge. The patient stated that there is complete freedom from the pain he formerly experienced. He also said that he recently spent a two weeks vacation on his father's farm and while there helped with the farm work without experiencing any discomfort whatever from the physical effort.

CASE 4—Mrs. M. O., a white woman aged 60, was admitted to the Charleston General Hospital April 13, 1944. She stated that she underwent two operations on the lower part of the abdomen between twenty and thirty years ago, at one time having her appendix removed and at another having a ventrofixation of the uterus. Physical examination showed two incision scars in the lower part of the abdomen. In the area between these, there was a moderate herniation. Pelvic examination showed a cystocele, grade 3 to 4, and prolapse of the uterus, grade 1. The perineum was in fair condition. A moderate senile vaginitis was apparent.

On April 14 conization of the cervix and repair of the cystocele were done. The cystocele was repaired with use of local (procaine hydrochloride) anesthesia. On April 18 the patient underwent subtotal hysterectomy and suspension of the cervical stump by means of a strip of cutis taken from the edge of the abdominal incision. With this strip of cutis the cervix was anchored to the under surface of the lower rectus aponeurosis at about its point of attachment to the pubic arch. Incidental to the closure of the abdominal incision, the old incisional hernia was repaired, a cutis graft patch being used for reenforcement. The patient had a moderate degree of fever for about one week following the suspension operation, after which her temperature dropped to normal and remained so up to the time she left the hospital.

On March 3, 1945 this patient was readmitted to the hospital, complaining of recurrence of the uterine prolapse, which, she stated, took place about six months after her last operation. Vaginal examination showed the presence of a definite recurrence of the prolapse. The results of the vaginal operation were good. Likewise, the incisional hernia had not recurred.

On March 8 this patient's abdomen was reopened along the line of the previous lower abdominal incision. The cutis graft used as reenforcement in the repair of the incisional hernia was intact and in place. The cervix had completely broken

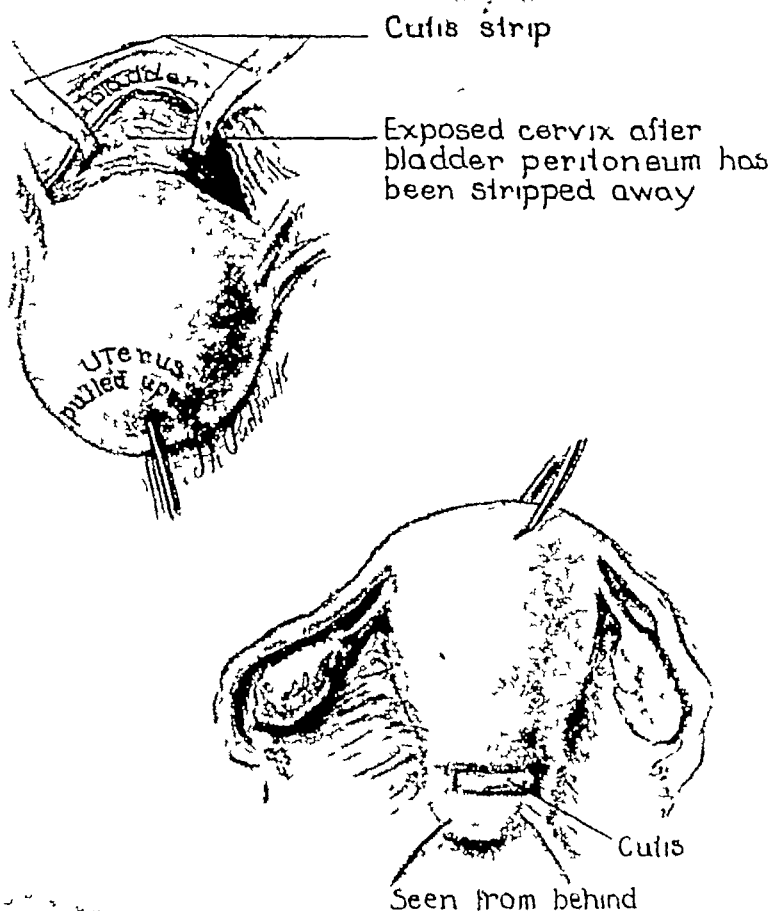


Fig 2 (case 4)—Cutis graft treatment of the cervix of the uterus

away from its moorings. The previously implanted cutis strip had apparently pulled entirely free from its base above the pubis and was lying, for the most part, over the right broad ligament, to which it was adherent. This strip of cutis was completely peritonized.

The upper portion of the cervical stump was mobilized and firmly drawn up back of the pubis. The fold of bladder peritoneum adjacent to the pubis had been previously incised and pushed downward from the posterior surface of the pubis for a short distance. A heavy strip of cutis, $\frac{7}{8}$ inch (2.2 cm) wide and of suitable

length, was taken from the anteroexternal surface of the right thigh. The ends of this cutis strip were carried under the periosteum of the tuberculum pubis at about the insertion of Poupart's and Cooper's ligaments. This cutis strip was carried partly through and partly under Gimbernat's and Cooper's ligaments at a point lateral to the tuberculum pubis. A similar maneuver was carried out on the opposite side of the pubic arch. The free ends of the cutis suture were then

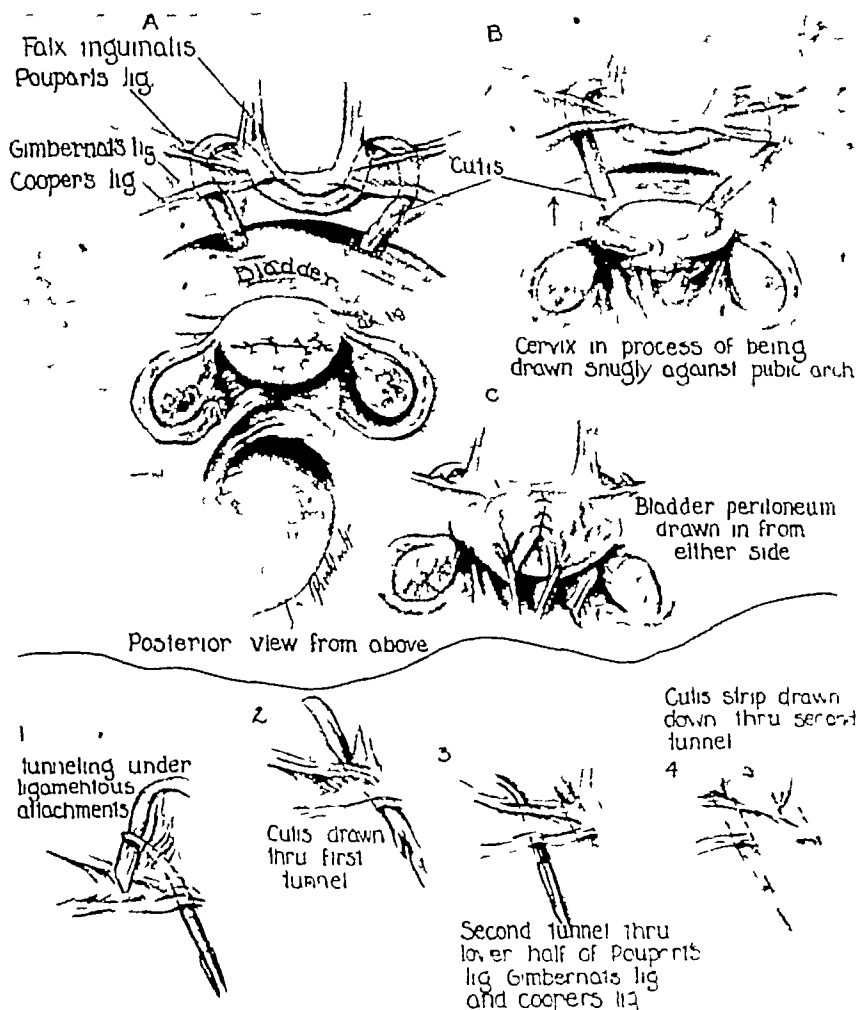


Fig 3 (case 4) —Details of procedure

carried through the cervical stump, which was drawn up in place behind the pubic arch, after which both free ends of the cutis ligature were anchored together with interrupted sutures of no 15 cotton thread. The edges of the peritoneum of the bladder were sutured over the point of suspension so as to render the cutis ligature and its immediate attachments extraperitoneal. The abdominal incision was closed in the usual manner.

The patient's temperature ran a normal course during the first five postoperative days, after which it rose to 100 F for two successive days. About this time the presence of a small, reddened area of skin in the region of the lower end of the incision was noted. This was thought to indicate a local area of dermatitis or cellulitis. The patient was given penicillin intramuscularly for three or four days. The redness of the skin disappeared, likewise, the temperature dropped to normal and remained so. The patient was discharged March 18, 1945.

On April 6, 1945 the patient returned to the hospital, complaining of a small, superficial, draining abscess at the lower end of the former abdominal incision. She was given penicillin by local instillations and also intramuscularly for a few days, after which the abscess was explored and one interrupted cotton thread suture recovered. When the patient was discharged from the hospital, on April 20, she was in apparent good condition, her temperature was normal and the drainage opening was nearly healed.

CASE 5—Mrs R P, a white woman aged 49, was readmitted to the Charleston General Hospital April 4, 1945, having had a previous admission Feb 26, 1944, for repair of a large, ventral postoperative hernia which developed following a previous laparotomy. At the time of the first attempt at repair of the hernia by Dr Bankhead Banks and me, a cutis graft was used for reenforcement. We closed the aponeurotic structures with single no 30 cotton thread sutures, tying the knots double throw, in accordance with our practice at that time. When applying the reenforcing patch of cutis over the area, we used interrupted sutures of no 40 cotton thread, tied in similar fashion, for the purpose of anchoring the cutis graft in position. This patient had primary healing of the wound and left the hospital in apparent good condition. During the next six months a recurrent hernia developed.

Operation was performed April 7, 1945 by Dr Bankhead Banks and me. On opening the former incision, we noted that the present hernia was much larger than the original one and that apparently neither the sutures in the aponeurotic edges nor those that were used to anchor the patch in position on stretch had held. The cutis graft had become completely detached from its former contact with the aponeurotic sutures on the left side and at both ends. Three or four sutures were visible on the right side of the graft. However, these were almost entirely pulled out. The graft looked healthy and in every way viable but had shrunk to about one fourth of its former size. The hernial bulge was approximately $6\frac{1}{2}$ inches (16.5 cm) in length and extended practically all the way from the umbilicus to the symphysis pubis. The spread in the central portion was $2\frac{1}{2}$ inches or more in width. The peritoneal portion of the hernial sac was plicated with numerous interrupted sutures, after which the edges of the aponeuroses were approximated with two rows of interrupted sutures of no 15 cotton thread, each of which was tied with a triple throw knot, the second row of these interrupted sutures was inserted about $\frac{3}{8}$ inch (1 cm) back of the first row. An onlay graft of cutis tissue, approximately $1\frac{3}{4}$ inches wide by 7 inches (17.7 cm) long, was sutured in place under firm tension with triple throw tied interrupted sutures of no 30 cotton thread, after which the lower portion of the subcutaneous fatty layer adjacent to the incision was sutured firmly down to the center of the graft. The skin was closed with vertical mattress sutures. A moderate pressure dressing was applied.

This patient had a normal convalescence and was discharged from the hospital about two weeks following operation. To date there is no sign of recurrence of the hernia.

CASE 6—Miss D W, a white woman aged 19, was admitted to the Charleston General Hospital, Oct. 12, 1944, with a history of recent severe injury of the left knee resulting from an automobile accident. Roentgenologic examination showed pronounced lateral and moderate posterior dislocation of the distal end of the femur in relation to the tibia. There were several chip fractures along the medial condyle of the distal end of the femur. There was obviously a gross dislocation of the left knee joint, resulting in a flail joint. An irregular laceration of the skin over the knee was present. The relation of the femoral condyles and the head of the tibia was exceedingly unstable, so much so that it was with considerable difficulty that sufficient fixation of these structures could be maintained while a plaster cast was being applied to the leg and thigh. Roentgenologic examination indicated that the relative position of the head of the tibia and the femoral condyles was not very good. After a few days the cast was removed. Further adjustments were made, and a long leg cast was snugly applied. Later this cast was wedged so as to correct a medial angulation at the knee.

Operation—An operation was performed on Nov. 30, 1944 by Dr. George Tsunekawa and me for the reconstruction of the crucial ligaments of the knee. This operation was based in part on a technic described by Albee,⁸ in which fascia lata had been used for the replacement of ruptured crucial ligaments of the knee.

Apparently both anterior and posterior crucial ligaments had been ruptured. (From the extreme instability noted at the time of admission, it was believed that all the major ligaments of the knee had been put out of commission.) A parapatellar incision was made on the lateral side of the knee. The tibial tubercle was chiseled free from the anterior surface of the tibia. When the patella was retracted medially, an excellent exposure of the interior of the knee joint was given. A $\frac{3}{8}$ inch hole was drilled through the side of the condyle and into the intercondylar space. Likewise, a similar drill opening was made through the head of the tibia, extending back to about the center of the articular head of the tibia. A strip of cutis 7 inches long by $1\frac{1}{2}$ inches wide was used. This was held taut while being keyed into position by bone wedges both above and below. In addition to this, the ends of this strip of cutis were overlapped and fastened together with multiple interrupted sutures of no. 30 cotton thread. While it had been extremely difficult to hold the knee in anything like correct position for application of the plaster cast at the time of operation, as a result of local healing processes, the knee was to a considerable extent fixed in a relatively normal position.

On Oct. 22, 1944, the patient was discharged from the hospital, wearing a leg-thigh cast, which she wore for about eight weeks, after removal of which she wore a knee brace for several weeks and went about on crutches.

Recent reports from this patient indicate that she has had a satisfactory result and is able to use her leg in a normal manner.

CASE 7—S F, a white man aged 45, was admitted to the Charleston General Hospital, Oct. 17, 1944, with a history of severe trauma to the calf of his right leg, after which a painful bulge developed on the back of the injured leg below the knee.⁹ This swelling was particularly apparent when the patient put his weight on the leg in question. He stated that when the leg was at rest the swelling dis-

⁸ Albee, F. A New Operation for the Repair of the Crucial Ligaments of the Knee, *Am J Surg* 60 349-353 (June) 1943.

⁹ Simon, H. E., and Sacchet, H. A. Muscle Hernias of the Leg, *Am J Surg* 67 87-97 (Jan) 1945.

appeared. On palpation around the edges of the involved area, the aponeurotic margins could be felt. The hernial bulge was about $2\frac{1}{4}$ by $2\frac{3}{4}$ inches (6 by 6.9 cm).

Operation—At operation on Oct. 18, 1944, after the skin and subcutaneous fat were dissected away from the hernial area, it was noted that the aponeurotic structures over the gastrocnemius muscle were definitely ruptured along a central line on the posterior surface of the leg. The edges of the ruptured aponeuroses were brought together with interrupted sutures of no. 30 cotton thread, after which a cutis graft, which had been taken from the anteroexternal aspect of the thigh of the same side, was sutured into position on tension. The subcutaneous fat was sutured over the graft, after which the skin was closed with vertical mattress sutures. A pressure dressing of mechanic's waste was applied. This was kept in place for ten days.

A check-up on this patient Nov. 30, 1944 and a letter from his physician disclosed the fact that the region of the former hernia was free from pain and that the operative result had been satisfactory.

This patient was again admitted to the hospital Aug. 15, 1945, complaining of repeated attacks of cramping of the muscles of the right leg and also extreme discomfort in the area of the cutis graft repair, as a result of having been thrown violently to the ground while operating mining equipment.

At operation August 17, the previously placed cutis graft was found to be in excellent condition and apparently firmly attached at the edges. There was laxity in the graft, perhaps a little more than would be normally found in the aponeurosis over the gastrocnemius muscle. The skin graft was so firm and thick that it was found to be well nigh impossible to pass a surgical gut needle through it, and accordingly cervix needles were used in plicating the old graft.

An incision was made along the line of the previous scar over the calf of the right leg. The newly created aponeurosis was tightened up by plication with several interrupted cotton sutures. It was not thought advisable to place an additional cutis graft, as the one previously sutured into position was tough and resistant to tension.

The following cases are reported from the neurosurgical service of Dr. A. A. Wilson.

CASE 8—Mrs. F. M., a white woman aged 70, was admitted to the Charleston General Hospital, Sept. 9, 1943, with a history of having had evidence of a spontaneous subarachnoid hemorrhage some three weeks before admission. She made a fairly prompt recovery from the effects of the hemorrhage, although she continued to complain of diplopia and intense pain back of the right eye. A few days before admission symptoms developed indicating a paralysis of the third nerve on the right side. She was in this condition when admitted.

There were no other neurologic abnormalities. There was change neither in the field nor in the disk. It was felt with reasonable certainty that this patient had an intracranial aneurysm of the right internal carotid artery. Stage ligation of the common carotid artery was believed to be indicated.

Operation—The patient was operated on Sept. 15, 1943 by Dr. A. A. Wilson and me. The common carotid artery was exposed and clamped and the patient taken to the x-ray room, where 10 cc. of colloidal thorium dioxide (Thorotrast) was injected into the artery distal to the clamp, and roentgenograms were taken. This procedure clearly indicated the presence of an aneurysm. The patient was returned to the operating room, where a strip of cutis was wrapped thrice around

the artery and drawn tightly enough almost, but not entirely, to stop the flow of blood coming through. The ends of the cutis strip were firmly anchored with cotton sutures. The wound was closed with fine silk. The patient was immediately relieved of pain back of the right eye.

Operation (Second Stage)—On September 23, the operative wound was reopened and an attempt made to separate the encircling strip of cutis from the

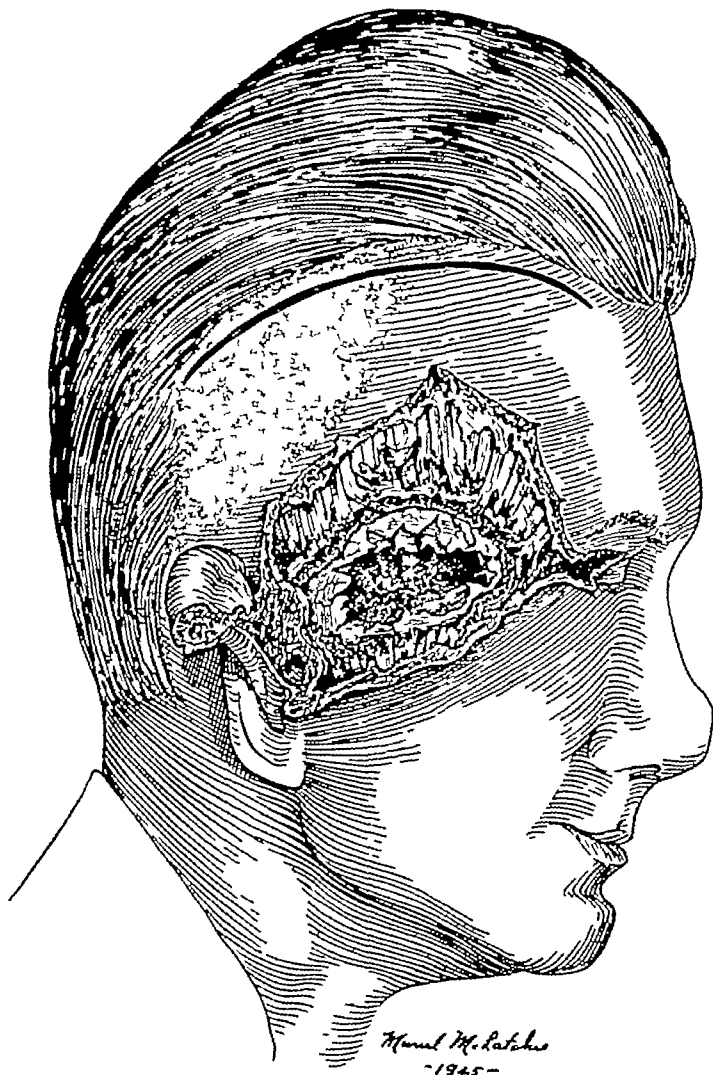


Fig 4 (case 9) —Cutis graft operation in right temporal area

artery. However, it was so completely fused with the walls of the vessel that the attempt had to be given up. In an endeavor to separate the strip of cutis from the artery, a tear was made in the artery. There was a free escape of blood, which was promptly controlled by the application of a clamp followed by a cotton ligature. The arterial trunk was then exposed a little farther down, after which it was ligated with umbilical tape.

Dr Wilson stated that this patient has continued to remain free from pain and, according to recent reports from her family physician and from her son, has apparently remained in good condition

CASE 9—E A, a 15 year old boy, was admitted to the Charleston General Hospital, Oct 28, 1944 He had received a shotgun charge (bird shot) at close

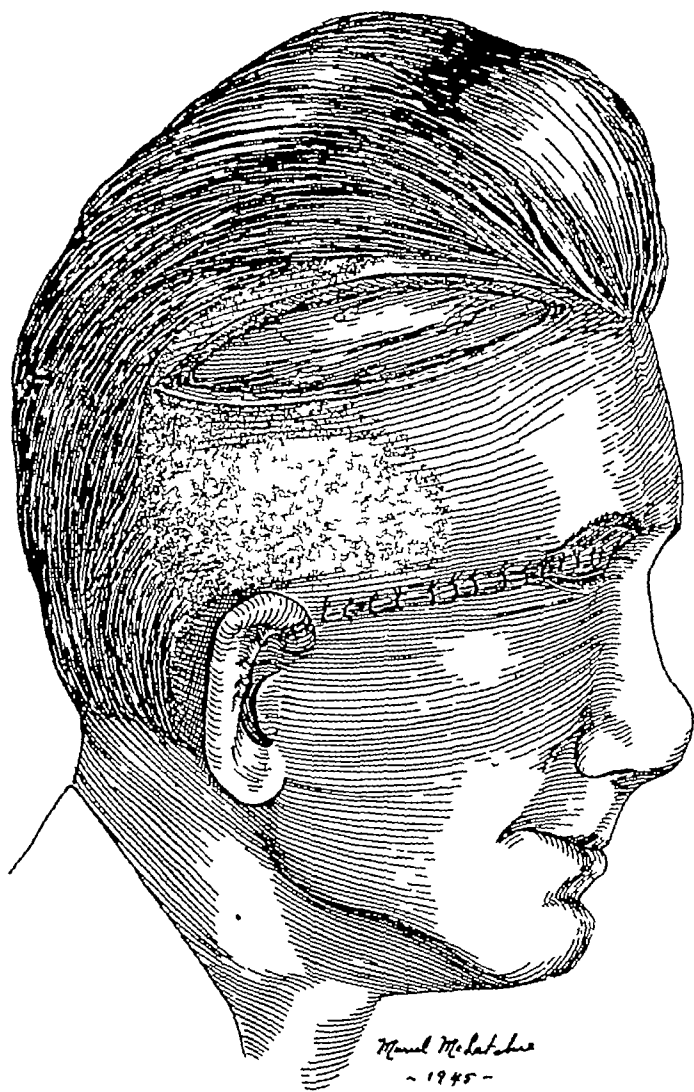


Fig 5 (case 9)—The dural rent closed by cutis graft patch and muscular aponeurotic structures closed by suturing

range in the right temporal area, which had caused extensive destruction of the soft tissue, bone, dura and brain The temporal muscle was extremely frayed, and the gap between the margins of skin was about 4 inches (10 cm) wide and began at the outer canthus, extending to and involving the right ear, which was torn through into the aural canal The right eye, but neither of the eyelids, was

destroyed. Excessive comminution and fragmentation of the temporal bone, ragged laceration of the dura and considerable maceration of brain tissue were present.

Operation—Operation was performed Oct 28, 1944, by Dr A A Wilson and Dr Josef Haber. After the dural rent was cleansed by irrigation followed by debridement, it was closed by a cutis graft patch about 1 inch (2.5 cm) square and the muscular aponeurotic structures were approximated by suturing. A sliding flap of adjacent scalp was brought down and sutured in place so as to cover the



Fig 6 (case 9)—Final results

large defect in the skin. The area from which the sliding flap was brought down was covered with a split thickness graft. The result in this case has been extremely satisfactory.

CASE 10—J B, a white man aged 62, was admitted to the Charleston General Hospital, Jan 30, 1945, complaining of ringing in his ears and of a painful and pronounced exophthalmos of the left eye. The conjunctiva was intensely injected and edematous. The physician who referred this patient stated that he had fallen down a flight of steps in a hotel Dec 3, 1944 and had apparently suffered a severe

concussion In a letter concerning the patient, he stated that examination a short time after the injury showed a laceration of the skin approximately 3 inches (7.6 cm) long in the right parietal region, pronounced edema of the eyelids and a moderate exophthalmos of the left eye Roentgenologic examination at that time revealed a linear fracture beginning in the midportion of the right temporal bone and running forward and downward There were no signs of paralysis The patient was restless A slight elevation of temperature was present, and the pulse was rapid Spinal puncture had been done Dec 6, 1944, and 15 cc of reddish fluid was removed, the fluid apparently being under pressure Subsequent punctures were done until the fluid returned clear, after which the patient showed considerable improvement in his mental and general condition and became, to some extent, cooperative Later spinal punctures apparently did not bring about further improvement

Ophthalmoscopic examination showed evidence of increased intracranial pressure, with edema and choking of the left disk Examination indicated further that there was partial vision in the right eye, with pronounced edema of the lids and conjunctiva of the left There was apparently no vision in the left eye The impression noted was that of severe concussion, with probable local laceration of brain substance

Dr Wilson made the following notes "There is complete left ophthalmoplegia with pronounced exophthalmos and extreme edema of the conjunctiva Vision in the right eye is extremely poor, and the disk is pale, although no evidence of intracranial pressure is noted The patient remembers none of the events of the accident

"There is a loud bruit, which can be heard all over the forehead and adjacent areas of the head but perhaps is heard best around the left eye, hence it is assumed that the patient has an arteriovenous fistula Roentgenologic examination shows nothing other than a linear fracture in the right temporal area, the optic foramen is apparently normal Lumbar puncture showed a small amount of xanthochromic fluid under low normal pressure, with a negative serologic reaction A two stage ligation of the left common carotid artery is proposed"

Operation—Operation was performed on Jan 31, 1945, by Dr A A Wilson and me With the patient under anesthesia induced with 1 per cent procaine hydrochloride, an incision was made in the left side of the neck and carried downward so as to expose the common carotid artery just below its bifurcation A rubber-shod clamp was applied to the carotid artery for twenty minutes, with no untoward reaction A $\frac{1}{2}$ inch (1.3 cm) wide strip of cutis was wrapped twice around the common carotid artery and held sufficiently taut almost but not quite to obliterate pulsation This strip was firmly anchored in position with interrupted cotton thread sutures At that point in the operation, it was noted that the bruit immediately ceased The wound was closed in layers with fine silk

Operation (Second Stage)—On Feb 8, 1945 the wound of the previous operation was opened and the carotid artery exposed Three ligatures of heavy black silk were tightly tied around the encircling strip of cutis, after which the weak pulsations distal to the cutis ligature ceased The wound was closed in layers with fine black silk

After the first stage operation, the patient's temperature rose to 99.6 F However, during the entire stay in the hospital his temperature did not rise above 99.8 F He was discharged February 28, somewhat improved

Dr Wilson stated that this patient has continued to show improvement, that there has not been a return of the bruit, that the exophthalmos in the left eye has

entirely disappeared and that the patient has been able to return to his office and to do some work

Up to the present time, there have been 129 cases in which cutis has been used by my surgical associates and me at the Charleston General Hospital, to wit 6 cases of epigastric hernia, 27 of abdominal incisional hernia (1 of these was a case of secondary operation for recurrence), 1 of umbilical hernia, 28 of direct and indirect inguinal hernia, 1 of diastasis of the buccinator muscle (glass blower's hernia), 2 of pronounced bulging of the lower abdominal aponeurosis, 1 of herniation of the gastrocnemius muscle, 28 of suspension of the uterine cervix for the relief of prolapse (2 of these were cases of secondary operations for recurrence), 1 of suspension of the urethra for the relief of urinary incontinence (modified Goebell-Stoeckel-Aldredge type of operation), 9 of wobbling knee, 2 of reconstruction of crucial ligaments of the knee, 3 of fracture of the patella, 1 of approximation of the third and fourth metacarpal bones in clawhand, 1 of fracture of the ulna, 1 of ankylosis of the jaw, 3 of sternoclavicular dislocation, 1 of luxation of the acromial end of the clavicle, 1 of repair of a contour defect over a depressed area in the frontal bone, 1 of implantation after sequestrectomy for chronic discharging sinus of the foot, 2 of stage ligation of the common carotid artery, 1 of partial occlusion of the femoral artery for the control of popliteal aneurysm, 3 of replacement of torn dura, 4 of sigmoid colostomy for a bridge to support the bowel, and 1 of implantation for the relief of loss of bowel control due to destruction of the sphincter muscle following the Whitehead method of hemorrhoidectomy

COMPLICATIONS AND RESULTS

In my personal series of 81 cases, there have been 4 cases of minor infection of the wounds and 3 cases in which a small area of apparent cellulitis developed near the operative incision (patients in these last cases were successfully treated with penicillin therapy) There were 3 instances of moderate serous drainage In these the patients were treated by protection of the involved area with screen wire shields Two incisions healed promptly However, one continued to drain a little for several weeks but did not suppurate One of the patients in our early case had a hematoma, which healed promptly after removal of the blood clot There has been 1 death, probably due to anesthesia The patient, a robust-appearing young man, accustomed to heavy manual labor, died while under ether anesthesia at the close of a brief operation for the cutis graft fixation of a coracoclavicular dislocation, autopsy was not performed In no case was there loss of the graft

Among the 48 patients that have undergone cutis graft repair by various other members of our surgical staff, there have been 2 deaths One

of the patients, an obese woman in poor general condition and suffering from a large, strangulated umbilical hernia, was brought to the hospital at night for an emergency operation. After the strangulated bowel had been released and found to be viable, a cutis graft repair was undertaken. At the end of this procedure, which took a considerable length of time, this patient died, apparently from exhaustion and shock (permission for autopsy was not obtainable). The other death was due to pneumonia incidental to an operation for suspension of the cervix, autopsy in this case showed what was apparently an acute miliary flare-up resulting from an old healed tuberculosis, of which no history was obtainable. Among other cases in this group, there have been 2 rather severe infections of wounds. In 1 of these (in which a double thickness graft was used), a graft was lost. Apparently there has not been a recurrence of hernia in this case. In another case in this group a small abscess developed beneath the graft and adjacent to the previously amputated hernial sac two and one-half years after operation. At the time of incision of the abscess, a specimen was taken for biopsy purposes. This showed the graft to be sound, well vascularized and completely converted into fibrous tissue. The abscess was completely underneath the graft and apparently originated about the external surface of the ligated sac. A culture of the pus showed *Staphylococcus aureus*. There was no suggestion of recurrence of the hernia. Neither was there anything about the abscess to indicate any connection with an epidermoid cyst. So far, with 2 exceptions, we have been unable to learn of the recurrence of hernia in any case in which a cutis graft repair has been carried out (cases 1 and 5).

The results following cutis graft reenforcement of the collateral ligaments for the treatment of wobbling knee have been good for the most part. Recent reports in 3 cases show excellent function in 1 case, in the second case the result may be classed as good, in the third case a second operation was necessary, after which a slight wound infection developed. The patient in the last case now has about 75 per cent function. Likewise, in the 2 cases of reconstruction of the crucial ligaments the results have been satisfactory.

SUMMARY

We have checked our cases, 129 in number, in which cutis grafts have been used. In this group there were 3 deaths: 1 due to anesthesia, 1 to postoperative pneumonia and 1 to exhaustion and shock after a prolonged operation. In the last-mentioned case, 1 of strangulated abdominal incisional hernia, the procedure possibly could have been handled safely by the stage operation method. There were 2 cases of rather serious infection, in 1 of these a graft was lost. Of the 9

cases of wobbling knee in which cutis graft repair has been done, the results in 6 cases have been reported as good. One patient is still under observation, 1 we were unable to follow up. In the remaining case, the first attempt at operative repair with cutis was unsuccessful. After the second operation, a slight infection developed in the wound. This patient now has about 75 per cent function. In the 2 cases of reconstruction of the crucial ligaments of the knee, the results were good.

CONCLUSIONS

A study of our cases of cutis graft repair shows an operative mortality of 2.32 per cent and a recurrence rate of hernia of 3.2 per cent.

The greatest value of the cutis graft probably lies in its use in the treatment of incisional hernia. Its next greatest field of usefulness probably lies in the cure of prolapse of the uterus. It undoubtedly has considerable value when used for reenforcement and replacement purposes in the repair of ruptured ligaments of the knee. It is of distinct use in the reconstruction of joints and in the stage ligation of large arteries. It probably will be found to be superior material for the stage or permanent ligation of the aorta and for the reenforcement of certain types of aneurysm.

REVIEW OF UROLOGIC SURGERY

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ALEXANDER B HEPLER, M D
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ROCHESTER, MINN
AND

VINCENT J O'CONOR M D
CHICAGO

(Concluded from Page 246)

PROSTATE GLAND

Transurethral Resection—Latchem and Emmett⁶ stated that age is no longer regarded as a contraindication to prostatic operation and that patients of advanced age tolerate transurethral resection almost as well as younger men. During the nine years from 1934 to 1942, inclusive, 345 patients of 80 or more years were treated by transurethral resection at Mayo Clinic. Seventy-four of these patients were 85 or more years of age, and 7 were 90 or more years. On admission, the value for blood urea of 76 of the 345 patients was more than 50 mg per hundred cubic centimeters, whereas for 20 it was more than 70 mg per hundred cubic centimeters.

The incidence of associated disease in these elderly patients was high. Forty-two patients were considered poor risks for surgical procedures because of cardiac disease. Two had had cerebrovascular accidents previously, and 1 had paralysis of the lower extremities. Twenty of these patients were suffering from diabetes mellitus. Other associated diseases were too numerous to mention.

The incidence of prostatic malignant lesions in this age group is interesting. In 104 cases (30.1 per cent) the tissue removed at the time of resection was malignant. In another 16 it was felt that the prostatic lesion was definitely malignant, yet the tissue removed was

26 Latchem, C W, and Emmett, J L. Transurethral Resection for Men Eighty or More Years of Age, *J Urol* 53 482-485 (March) 1945

reported by the pathologist to be benign. In most of these 16 cases the carcinoma was no doubt deep in the posterior lobe and was not encountered at the time of resection. If these 16 cases are added to the 104, it makes a total of 120, or more than a third of the group, in which the prostate was carcinomatous. This incidence of carcinoma of the prostate in men of this age group, therefore, is more than twice that of an unselected group of patients who undergo prostatic operations.

More than 30 Gm of tissue was removed in 123 cases (36 per cent), and more than 100 Gm was removed in 2 cases.

The operative results proved satisfactory. Two hundred and fifty-six patients (74 per cent) obtained excellent results. Another 43 patients (12 per cent) were improved. Fourteen patients secured poor results, whereas the results were not noted on the records of 23 patients. There were 9 deaths in the hospital among these aged patients, a mortality rate of 2.6 per cent. This compares favorably with the mortality rate of 1.2 per cent for the entire group of 7,971 patients subjected to transurethral resection at the clinic for the same period, 1934 to 1942 inclusive.

One of the greatest factors which contributes to the low morbidity and mortality of transurethral resection in this group of aged patients is the brief preoperative and postoperative period of hospitalization. Another factor is that most of these patients are confined to bed for a period not exceeding twenty-four to forty-eight hours after operation. Of the entire group of 345 patients, 206 were hospitalized less than four days previous to transurethral resection and 306 were hospitalized less than one week. After operation 103 patients were confined to the hospital one week or less, and two thirds of the entire group were confined to the hospital for a period not exceeding twelve days. Only 36 patients required postoperative hospitalization for more than twenty-one days.

When the extreme age and the average general condition of these patients are considered, transurethral resection deserves commendation. It has completely changed the prognosis for the aged patient suffering from prostatism. Such a patient may now elect to have surgical relief of his prostatic obstruction, knowing that his chances of relief are extremely good and the operative risk is minimal.

Emmett²⁷ stated that syphilis of the central nervous system (including locomotor ataxia) is not the important etiologic factor in urinary retention that it previously was supposed to be. Although locomotor ataxia may produce vesical atony in many cases, obstruction of the vesical neck is present in most cases, and in considerably more than

27 Emmett, J. L. Transurethral Resection in Treatment of True and Pseudo Cord Bladder, *J Urol* **53** 545-564 (April) 1945

90 per cent of the cases the vesical dysfunction can be relieved completely by transurethral resection of the vesical neck

Urinary retention in young adults, which formerly was regarded as a "neurogenic bladder" or atypical "cord bladder," is nearly always due to congenital obstruction of the vesical neck. In some cases slight myelodysplasia may be associated with spina bifida occulta. This lesion may produce a mild type of autonomous bladder, with just enough hypertrophy of the detrusor muscle to be manifest as a hyperplasia of the vesical neck. In either case, transurethral resection will relieve the condition. Even though obstruction of the vesical neck is not especially apparent on cystoscopic examination, transurethral resection should be tried, as the obstruction often is not apparent until after the resection is begun.

True "cord bladder," which results from a bona fide lesion of the spinal cord, presents an interesting surgical problem. In practically all cases the detrusor muscle is hypertonic and hypertrophied to some degree, the bladder is trabeculated, residual urine is present and there is some type of active urinary incontinence. On the basis of the theory that the hyperplasia of the portion of the detrusor muscle around the vesical neck may be in part responsible for the residual urine, the possibility of transurethral resection is attractive. The possibilities of such treatment seem to be encouraging.

Emmett has been disappointed in the use of cystometry and has abandoned its use as a diagnostic aid. He feels that more accurate information can be obtained from the patient's history, by physical and neurologic examination, by determination of the amount of residual urine and by cystoscopic examination.

Rodriguez Diaz²⁸ stated that the general value of transurethral resection is enhanced by refinements in the technic of operation which enable the surgeon to perform it with increasing facility and safety. Employment of a resectoscope that can be operated with one hand, permitting finger tip handling, is advantageous over the more cumbersome and less exact methods of operation that are necessitated by instruments employing pistol grip handles. Postoperative venous bleeding can be effectively controlled by the use of hemostatic agents, such as thrombin applied topically, which are instilled directly into the fossa at the end of the operation. The advantage of this method of controlling postresection bleeding is reflected in the abandonment of frequent vesical irrigation that heretofore has been a necessary part of the postresection routine management.

²⁸ Rodriguez Diaz, L. H. Some Notes on Advances of the Technique of Transurethral Prostatic Resection, *J. Urol.* **53**: 594-599 (April) 1945.

Palomo²⁹ reviewed 40 consecutive cases in which thrombin was used after transurethral resection. Thrombin (5,000 or 10,000 units diluted in 30 cc of sterile water) was instilled in the prostatic bed, the three way Cochrane catheter being used. Perfect results were obtained in 33 cases. In the remaining 7 cases, the results were unsatisfactory. The poor results in these cases were due not to the thrombin but to the usual complications of transurethral resection.

The advantages of the use of thrombin after transurethral resection may be summarized as follows. There is no postoperative hemorrhage. The patient is able to be up in a chair the day after operation. It is unnecessary to have a nurse irrigate the bladder every ten or fifteen minutes or to irrigate it continuously, as is done in some clinics. This saving in nursing care is of distinct advantage in a ward. Minimal irrigation results in decreased irritation of the bladder, so that there is no postoperative vesical spasm. There is a saving of equipment and solutions. The postoperative hospitalization is shortened (also of definite importance in a ward).

Prostatectomy—Rose³⁰ stated that suprapubic prostatectomy even on senile patients, who may be considered unfavorable surgical risks from the standpoints of senility, cardiovascular disease and injury of the kidney due to back pressure, can be performed with low mortality, little surgical shock or pain, short hospitalization and definitely lessened expense provided that operation is not delayed, all unnecessary trauma and mucosal irritation are avoided and surgical measures are used to prevent bleeding and aid in rapid closure of the bladder.

In 90 per cent of all cases, cystoscopy is followed immediately by one stage suprapubic prostatectomy for relief of infection and urinary obstruction. The operation is uncomplicated by preoperative or postoperative catheterization, vesical decompression or hemostatic catheters, bags and packs. Sulfonamide drugs, penicillin and pentothal sodium are valuable allies. The surgical technic is designed to control hemorrhage and insure early closure of the bladder. Normal vesical function frequently is reestablished within seven to ten days. The majority of patients are dismissed within two weeks.

The two stage operation is used only in the cases in which infection has caused severe damage to the kidney, in cases of cardiac decompensation and in cases in which cystoscopy discloses malformation of the bladder.

29 Palomo, A. Evaluation of Thrombin Following Transurethral Resection, *J Urol* **53** 590-593 (April) 1945.

30 Rose, D. K. Simplified Suprapubic Prostatectomy, *J Urol* **53** 470-474 (March) 1945.

McCrea³¹ made a study of 367 cases in which operation was performed for benign hyperplasia of the prostate gland. The following operations were performed: suprapubic enucleation in 217 cases (59.1 per cent), transurethral resection in 135 cases (36.7 per cent) and perineal prostatectomy in 15 cases (4 per cent). These operations were performed by seven urologic surgeons in two hospitals.

Most of the patients were between 60 and 70 years, the average age was 63.2 years. The youngest patient was 43 years, and the oldest patient was 93 years. Of the 367 patients, 307 were in wards and 60 were in private rooms. Fifty-five of the 58 patients who died before they were dismissed from the hospital were ward patients. The causes of death were as follows: cardiac failure in 32 cases, acute pyelonephritis in 9 cases, bronchopneumonia in 6 cases, cerebral hemorrhage in 2 cases, necrosis of the bladder in 2 cases and uremia, pulmonary atelectasis, carcinoma of the stomach, carcinoma of the bladder and embolism in 1 case each. The type of operation that was performed in these 58 cases was as follows: suprapubic enucleation in 36 cases, transurethral resection in 19 cases and perineal prostatectomy in 3 cases. The mortality rate according to the type of operation that was performed was as follows: 20 per cent for perineal prostatectomy, 16.5 per cent for suprapubic prostatectomy and 14 per cent for transurethral resection. The average period of hospitalization was 32.6 days in one hospital and 27.5 days in the other hospital. Of the 367 patients, 31 per cent were in good health five years after they were dismissed from the hospital.

Carcinoma—Crane and Rosenbloom³² studied 340 cases of carcinoma of the prostate in order to determine the period of survival and subjective condition of the patients one month and one year after treatment. The patients were treated by nine separate methods. Subjective improvement was present earliest when castration or estrogen or both castration and estrogen were used with transurethral resection. When employed with transurethral resection, castration alone is more effective than estrogen alone, estrogen does not substitute for castration but only reinforces it. Transurethral resection combined with castration and estrogen produced the earliest subjective improvement and the longest median survival time in this series. The treatment of choice in carcinoma of the prostate (except in cases in which the patients are observed in an early stage of the disease) is thorough transurethral resection, castration and continuous administration of diethylstilbestrol.

31 McCrea, L. E. The End Results of Prostatectomy. A Five-Year Survey, *J Urol* **53** 466-469 (March) 1945.

32 Crane, J. J., and Rosenbloom, D. Treatment of Carcinoma of the Prostate Gland. A Comparative Study, *J Urol* **53** 411-414 (Feb.) 1945.

Parlow³³ reported 75 cases of advanced cancer of the prostate in which radical perineal prostatectomy was not indicated because the disease was not confined within the capsule of the prostate. Orchiectomy was done in all of these cases. In 18 cases, this operation had no effect on the course of the disease and did not produce any relief from pain. Diethylstilbestrol was given in these cases, also without effect. In the remaining 57 cases there was immediate clinical improvement after orchiectomy, including relief of all metastatic pain. In 21 of these cases, examination showed regression. Of the 57 patients, 43 had a recurrence of symptoms in eight to thirty months and 22 of these patients had a complete clinical regression of the carcinoma.

Determinations of serum phosphatase were made prior to orchiectomy in this series of cases, all but 18 of the 75 patients had a definite elevation of the serum phosphatase, in 1 case the value was 155 units (King-Armstrong). After orchiectomy, the value for serum phosphatase paralleled the clinical course, in many cases, a "return" of the carcinoma was indicated by a rise in the value for the serum alkaline phosphatase before digital examination indicated recurrence of the disease in the prostate. Diethylstilbestrol, when given in these cases, relieved symptoms but did not control the progress of the disease.

One patient, a man of 70 years, who had complete clinical disappearance of the carcinoma and a normal concentration of serum phosphatase values after orchiectomy, died of pneumonia six months after operation. At necropsy, microscopic examination of the prostate revealed carcinoma cells "enmeshed" in fibrous tissue.

On the basis of the results in this series of cases, the author concluded that, since advanced carcinoma of the prostate may completely regress after orchiectomy but later become activated, radical perineal prostatectomy should be done when the carcinoma shows complete clinical regression and when the serum acid and alkaline phosphatase values are normal. It is hoped that at a later date results of such a procedure will be reported.

Tuberculosis—Diez³⁴ reported 4 cases of cavernous tuberculosis of the prostate which illustrate how easily this condition can be overlooked by the surgeon or be masked by the presence of tuberculosis in other parts of the urogenital apparatus. The comparatively small number of cases in which the prostate is the sole organ affected by the disease, its lesser gravity in comparison with other lesions and its lack of clinical individuality seem to be the chief reasons why communications on this

33 Parlow, A. L. Advanced Cancer of the Prostate. A Consideration of the Value of Radical Prostatectomy in Selected Cases, *New York State J. Med.* **45**: 383-385 (Feb. 15) 1945.

34 Diez, M. M. Cavernous Tuberculosis of the Prostate, *Arch. españ. de urol.* **1**: 93-98 (July) 1944.

subject are so few. Another reason may be the limited means for its treatment that are at the disposal of either the surgeon or the physician.

Among the facilities for its diagnosis that are now available, none can compare with urethrography by a contrast medium. Rectal palpation gives no satisfactory details of the condition of the lesions, and urethroscopy, equally unsatisfactory, is, in addition, not without danger. As a rule, the roentgenographic images of the cavities in tuberculosis of the prostate are more sharply outlined than those due to other causes. Diez employed a syringe having a capacity of 20 cc. to which is attached a piece of rubber tubing 3 to 4 cm. long. He then slowly injected 15 cc. of the opaque substance, after which roentgenograms were made. If a spasm of the external sphincter of the urethra is suspected, which would prevent passage of the fluid, anesthesia with the hydrochloride of benzoyldimethylaminomethylpropanol (stovaine) is used in advance. In the author's 4 cases, roentgenograms illustrated graphically the presence of tuberculous cavities in the prostate.

Alfonso and Emilio de la Peña³⁵ reported 8 cases of tuberculosis of the prostate gland, in 7 of which there was coexisting renal tuberculosis. There were signs of urinary tuberculosis in all but 1 case. In this case, the patient had had pulmonary and genital tuberculosis which had apparently healed. The prostate gland was completely calcified when the patient was examined. Total destruction of the prostate ("forebladder") is always the result of renal tuberculosis. Removal of the renal focus usually results in the healing of the prostatic process. So-called "forebladder" results in incontinence of urine, which may disappear spontaneously or may require surgical treatment. Hematogenous invasion of the prostate without involvement of the urinary tract may be benign, although there is always the possibility of tuberculous meningitis as a result of sexual excesses. Diagnosis is readily made by means of cystourethrograms. Treatment of tuberculosis of the prostate should consist in eradication of other foci—especially an infected kidney—and general measures (calcium and vitamins) together with vaccines and intravenous administration of compounds of copper and urea.

Calculi.—From a brief of the literature Nygaard and Weber³⁶ found that there is "no standard method of approach" in the surgical treatment of prostatic calculi. In the case reported, the patient was a man of 63 years. Urinary symptoms, frequency, nocturia and some dysuria had been present for more than a year, rectal examination showed "a rather pronounced" enlargement of the prostate and crepitation characteristic of prostatic calculi. Preliminary cystostomy was done.

35 de la Peña, A., and de la Peña, E. Tuberculosis of the Prostate, *Brit. J. Urol.* **16** 125-132 (Dec.) 1944.

36 Nygaard, K. K., and Weber, E. W. Total Perineal Prostatectomy for Endogenous Prostatic Calculi, *New York State J. Med.* **44** 2720-2722 (Dec. 15) 1944.

This was followed by prostatectomy by the perineal route. At operation, one large stone and numerous small ones were found to be lodged in the tissue of the apex of the prostate, this rendered the apex unsuitable for anastomosis with the vesical neck, and a total rather than a subtotal prostatectomy was done. The patient made a good recovery and has since been free from all symptoms. The authors noted that total prostatectomy may be necessary in some cases of diffuse formation of calculi in the prostate, especially if the apex is involved. They said that this seems to be of some significance in considering the surgical approach to be used in such cases.

The occurrence of concretions in the prostatic utricle is not mentioned in the standard textbooks, cases have been reported in the literature, however. If such concretions become impregnated with calcium, they may be considered to be true stones. Penna reported 4 such cases. In the case reported by Dreyfuss,³⁷ the patient had recurrent urinary obstruction and the prostate was found to be normal (confirmed by biopsy). An attack of acute urinary obstruction more than two years after the prostatectomy caused his death. At necropsy, a stone was found in the prostatic utricle. This was the cause of the urinary obstruction. As there was no abnormal communication between the utricle and either the ureters or the spermatic ducts, it is justifiable to conclude that the stone was primary in the utricle. Several corpora amylacea were found in microscopic sections and indicated that the concretion in the utricle had formed in the same way as prostatic stones do. No obstacle to the flow of urine could be found except the hard prominence at the verumontanum caused by the stone, it must, therefore, be concluded that this small concretion in the utricle was the cause of the recurring urinary obstruction and eventually caused the death of the patient.

PERINEAL FASCIA

Tobin and Benjamin,³⁸ in discussing Denonvilliers' fascia, stated that this tissue is derived embryologically from two sources of connective tissue (mesenchyme) (1) a layer surrounding the developing prostate and seminal vesicles and another layer around the rectum and (2) connective tissue (mesenchyme) adjacent to the mesothelium of the pelvic cul-de-sac of peritoneum. This peritoneal cul-de-sac extends to the level of the developing levatores ani muscles in young embryos.

Tobin and Benjamin suggested that the fascia around the rectal musculature be designated the posterior layer and that the fibrous mem-

37 Dreyfuss, M. L. Concretion in Prostatic Utricle Causing Urinary Obstruction, *Urol & Cutan Rev* 48 589-592 (Dec.) 1944

38 Tobin, C. E., and Benjamin, J. A. Anatomical and Surgical Restudy of Denonvilliers' Fascia, *Surg, Gynec. & Obst.* 80 373-388 (April) 1945

brane, which is derived from the pelvic cul-de-sac of peritoneum, be designated the anterior layer of Denonvilliers' fascia

In the perineal approach to the prostate, three potential fascial spaces could be developed between the rectum and prostate (1) between the rectal musculature and the rectal fascia (posterior layer of Denonvilliers' fascia), (2) between the rectal fascia and the anterior layer of Denonvilliers' fascia and (3) between the anterior layer of Denonvilliers' fascia and the fibromuscular covering of the prostate and seminal vesicles

Since the anterior layer of Denonvilliers' fascia and the fibromuscular covering of the prostate are whitish in appearance and are close together or adherent, either or both of these layers may constitute the glistening layer encountered in the perineal exposure of the prostate

If the fibromuscular covering of the prostate is perforated by cancer or abscess, the fibrous membrane may prevent direct spread of the malignant growth posteriorly to the rectum and may limit the spread of extravasated pus or urine

The fascial spaces between the rectum, prostate and seminal vesicles can be separated more readily in the specimens if they are not compressed by urethral or rectal instrumentation in the first stages of the perineal approach

Wesson³⁹ said that Buck's and Colles' fasciae only recently have been recognized as anatomic entities. Embryologic, anatomic and experimental studies have proved that Buck's fascia and the tunica albuginea of the penis are separate structures and that Colles' fascia is a distinct entity. The mode of extension of a hemorrhage within Colles' fascia has been determined, and it has been found that abscesses within Buck's fascia are narrowly restricted. Wesson reported 4 interesting cases which illustrated the restricting and protecting powers of the perineal fascia

TESTIS

Tumors—Vermooten⁴⁰ made a statistical analysis of a series of 62 cases of tumors of the testis seen during a two year period in an army hospital. His analysis indicates that there is a greater incidence of this type of lesion in army personnel than among civilians, however, it is felt that this is due to the easy access which a soldier has to medical advice, to the frequent routine physical examinations and to the fact that a physically fit and active man is especially likely to notice an enlarged, hard or painful testis

39 Wesson, M. B. The Value of Buck's and Colles' Fasciae, *J. Urol.* **53** 365-372 (Feb.) 1945

40 Vermooten, V. Testicular Tumors, *Arch. Surg.* **50** 63-66 (Feb.) 1945

Trauma, except for drawing the soldier's attention to the tumor, bears no etiologic relationship to the lesion. A testicular tumor when first seen is frequently mistaken for some other lesion. The most common diagnostic error is to consider the tumor as epididymitis, orchitis or hydrocele. Eleven, or 18 per cent, of the tumors were benign.

In 51 cases of malignant tumor the patients were admitted to the hospital and treatment consisted in radical orchiectomy followed immediately by high voltage roentgen therapy. Thirty-six, or 72 per cent, of the 51 patients were living and had no clinical evidence of metastasis when this paper was written. Of these 36 patients, 16 have lived from one year to twenty-five months after operation.

Nation, Edmondson and Hammack⁴¹ stated that 26 cases of interstitial cell tumor of the testis have been reported to date, including the 3 cases which they reported. In 21 cases the tumor was benign, and in 5 cases it was malignant. In 1 of the 3 cases reported by these authors, the tumor was malignant and the patient was 82 years of age. In the other 2 cases the patients were 30 and 34 years of age respectively. One of the patients had gynecomastia which failed to regress after orchiectomy was performed. Each of the 6 children in whom tumors occurred had precocious bodily and sexual development. Three (15 per cent) of the adults had gynecomastia.

Interstitial cell tumors of the testis are usually nodular and yellow or yellowish brown. The microscopic picture is characteristic, there are well circumscribed groups of liver-like cells with rather small, round nuclei and many punctate nucleoli, some of which are eccentric.

It is believed that the manifestations of these tumors offer further proof that the interstitial cells of the testis are the primary source of androgen.

Beard and Hewit⁴² reported a case of rhabdomyosarcoma of the testis in which the patient was a white man, aged 20 years. The patient had noticed an enlargement of the left testis for several months. On examination, it was found to be approximately 10 by 6 by 6 cm. in size. It was stony hard and not tender. No evidence of metastasis was found. Orchiectomy was performed, and microscopic examination revealed a rhabdomyosarcoma. Two months later, roentgen therapy was applied to the abdomen. At this time, a mass was discovered in the upper left quadrant of the abdomen. Metastatic involvement of the thorax occurred, and the patient died approximately seven months after he first was seen.

41 Nation, E. F., Edmondson, H. A., and Hammack, R. W. Interstitial Cell Tumors of the Testis. Report of Three New Cases, *Arch. Surg.* **48**: 415-422 (May) 1944.

42 Beard, D. E., and Hewit, L. W. Rhabdomyosarcoma of Testicle. A Case Report, *J. Urol.* **53**: 344-346 (Feb) 1945.

URETHRA

Lesions of the Urethra of Women—Stevens⁴³ stated that urethral obstruction in the female usually is caused by stricture, most often at or just within the external urethral meatus. Polyps are also common, but unless they are large they are seldom important factors. Even small growths, however, occasionally may be responsible for such symptoms as urinary frequency, urgency and burning and hematuria and pain.

Stevens reported a case in which a woman aged 80 years complained of urinary frequency and dysuria. She had had a similar condition thirty years previously, at which time urethral dilation had given her relief. Cystoscopic examination revealed multiple polyps and a stricture at the external urethral meatus. She had 1,560 cc of residual urine. The urethra was gradually dilated so that it would admit a 20 F sound, and meatotomy was performed. The amount of residual urine decreased to 350 cc and a further decrease was expected as the vesical walls regained their tonicity.

In a second case, a large calculus was found in the urethra of a woman of 92 years. She had had urinary frequency for many years. Roentgenologic examination revealed a large shadow in this region, and urologic examination disclosed a stricture just inside the external urinary meatus. The stricture was incised, and the urethra was opened through the vagina. Three large calculi, weighing 18.6 Gm, were removed.

Stevens reported another case of urethral calculus in which the patient was a woman aged 42 years. This stone, which was removed through an incision in the urethra, weighed 17 Gm.

Stevens said that the majority of urethral stones originate in the kidneys and descend and become lodged in a diverticulum, in a pouch or behind a stricture in the urethra.

GONORRHEA

Jones⁴⁴ stated that the complement fixation test is useful in the diagnosis of gonorrhea only in cases in which microscopic examination or bacterial culture fails to disclose *Neisseria gonorrhoeae*, in cases in which the history or clinical observations are negative for gonorrhea and in cases in which there is a surgical, social or family problem. The complement fixation reaction may remain positive for months after laboratory and clinical findings are negative. Its use as a routine test must be condemned. Repeated subinfection inoculations of gonococci may cause

43 Stevens, W. E. Some Interesting Urological Conditions in Women, *J Urol* **53** 378-380 (Feb) 1945

44 Jones, W. R. The Value of the Complement Fixation Test to the Urologist, *J Urol* **53** 393-396 (Feb) 1945

the reaction to be positive. There can possibly be a cross fixation from other organisms of the genus *Neisseria*. The clinician and the technician must collaborate to keep reagents in balance. The test is of value in the hands of the urologist or other clinician who practices individual rather than group medicine and who makes a tentative diagnosis based on the history and the clinical observations and confirms this in the laboratory.

PENICILLIN THERAPY

Fleming,⁴⁵ who discovered penicillin, stated that it is a substance produced by a mold, *Penicillium notatum*. Culture fluid of some kind is put into a bottle, and then mold spores are put on the top of the culture medium. Growth takes place, not in a hot incubator but in the temperature of a rather uncomfortably hot room. The mold forms a thick felt on the top of the clear fluid, which turns yellow. (All the penicillin which is used is yellow, but the pure material has no color at all.) After a week or a fortnight the liquid is poured off, and this contains the penicillin. The treatment of this fluid for the purpose of extraction of the active principle varies with different manufacturers and also keeps on varying with the same manufacturer, because there is as yet no agreement as to the best method. The fluid is finally dried. In the course of purification a great many things are taken away from it which on injection might cause fever of some kind, and there is left a yellow powder, perhaps from 10 to 30 per cent pure. The culture medium varies, and so does the method of extraction, therefore, the impurities vary.

Penicillin has an extremely selective action in inhibiting the growth of some bacteria, whereas it has no effect on others. The more sensitive organisms are staphylococci, streptococci, pneumococci, gonococci, meningococci and *Bacillus diphtheriae*. *Bacillus coli*, *Bacillus influenzae* and many others are not sensitive. When a culture is taken which contains a large number of penicillin-sensitive and penicillin-insensitive organisms, it will be found that the former do not grow and the latter do.

All the old antiseptics were much more active against leukocytes than against bacteria. Penicillin was the first chemical Fleming had ever encountered which acted far more strongly on the bacteria than on the leukocytes. It had no harmful influence on the leukocytes, whereas against certain bacteria the crude culture fluid was more than twice as inhibitory as was phenol.

For use in the body, Fleming stated that sometimes the sodium salt and sometimes the calcium salt of penicillin is employed. To begin with, all the penicillin for injection was in the form of the sodium salt,

45 Fleming, A. Penicillin in Venereal Diseases, *Brit J Ven Dis* 20 133-136 (Dec) 1944

but later the calcium salt was used for intramuscular, intravenous and subcutaneous injection and has been found to be as suitable as the sodium salt. It has certain advantages in manufacture, and some day it may be used generally.

The salt can be applied locally in such a way that the penicillin comes into contact with the organisms. This calls for a certain ingenuity on the part of the surgeon. Consider, however, what happens with the systemic use of penicillin. It cannot be taken by mouth because it is destroyed by the gastric juices, it cannot be given by rectum because it is destroyed by the organisms in the rectum, therefore one must administer it intramuscularly, intravenously or subcutaneously.

Local treatment at present is not used extensively in cases of venereal disease, but in surgical practice it is prominent because it is an extremely economical way of using penicillin. Penicillin can be put on raw surfaces and can be injected into abscesses, boils and similar lesions. It stays in the abscess cavity in appreciable concentration for forty-eight hours or longer.

Penicillinase is a substance which is elaborated by many bacteria and which destroys penicillin. The destruction of penicillin by penicillinase has happened frequently when people have not used enough care in making up their solution to insure its sterility.

Lloyd,⁴⁶ in an editorial, stated that the extract of penicillin, although possessing the great advantage of reasonable solubility, is relatively unstable and is susceptible to alterations in pH . Thus, the active principle is destroyed by acids, alkalis or heat. It is therefore unsuitable for oral or rectal administration and to be effective must be given parenterally. Various methods, including continuous intravenous drip and intramuscular injection at intervals of three to four hours, have been used and tolerated, with excellent results. In the treatment of gonorrhea these limitations of the method of administration may prove to be no disadvantage, for irregular or inadequate dosage is much more frequently encountered in oral therapy, which is usually dependent on the patient, than in parenteral treatment.

The astonishingly efficient antibacterial properties of penicillin exhibited *in vitro* in high dilution against cultures of the pyogenic cocci were even surpassed in experiments by Sir Alexander Fleming by its action on cultures of gonococci.

This antibiotic substance seems to possess fundamental characteristics of outstanding practical value. For example, the extracts successfully inhibit the growth of some bacteria in astoundingly high dilutions. It differs from conventional antiseptics in that its activity is not affected

⁴⁶ Lloyd, V. E. Penicillin, editorial, *Brit J Ven Dis* **20** 131-132 (Dec.) 1944.

by the presence of serum, blood or pus, in addition, it appears to be entirely devoid of any deleterious action on the structures and cells of the human body. If this is so, it clearly attains ideals that have long been postulated for the perfect antiseptic. Many mold extracts are known to possess powerful antibacterial properties, but the extract of *P. notatum* appears to be unique in also being innocuous to the body tissues. It has been shown that the leukocytes are unaffected by concentrations much greater than those adequate to interfere with the growth of sensitive organisms.

The status of the use of penicillin in the treatment of syphilis is one of keen interest. Preliminary investigations of its effects on this disease in rabbits are said to indicate that it yields excellent results. The use of the compound in the treatment of primary syphilis in man is stated to have resulted in the rapid disappearance of *Treponema pallidum* and in the speedy healing of chancres, the positive serologic reactions were said to be reversed to negative at a satisfactory rate. However, much more evidence is required before any useful comment can be made. Meanwhile, physicians are awaiting the results of long term studies, which may prove that penicillin will soon have a great part to play in the treatment of early syphilis.

Suchet⁴⁷ considered the value of penicillin in the treatment of venereal diseases. He stated that the treatments have varied from single injections at intervals of ten minutes to multiple injections at intervals of a varying number of hours. He has also used the continuous drip method. No matter what the dose has been, his results have been surprisingly good. Nevertheless, in some cases there have been relapses which were not anticipated.

The suitable amount to be used for the treatment of gonorrhea appears to be between 100,000 and 120,000 units. What seems to be important is the time factor. In cases in which 120,000 units have been administered over a long interval, that is, perhaps 15,000 units every three hours until eight doses have been given, the results have been better than they would have been if the total dose had been given at once. Both the calcium and the sodium salts were used.

As a rule, no matter what the original dose, the gonococci disappeared within four hours and in some cases within one and a half hours. The next thing one noticed was that a few hours later the discharge increased in amount and became mucoid. A smear of this profuse discharge revealed masses of leukocytes but no gonococci. Gradually, the discharge cleared up. Some persons have reacted oddly to the treatment, the discharge has continued as long as eight days, and if they

⁴⁷ Suchet, J. Penicillin in Venereal Diseases, *Brit. J. Ven. Dis.* **20** 136-138 (Dec.) 1944

had been treated with sulfonamide drugs it would have been said that a relapse certainly would occur. These patients eventually were cured.

Organisms can be made resistant to penicillin, but, since gonococci are most susceptible to penicillin, this does not seem likely. Furthermore, the impression is gathered that a patient who previously has been treated with sulfonamide compounds and has failed to respond reacts better to penicillin than do patients who have not been treated with sulfonamide drugs.

Four patients who had gonococcic arthritis have been treated with doses varying from 700,000 to 300,000 units, and a man who received the smallest amount of penicillin—namely, 300,000 units in three days—did best of all. This man had been crippled for three and a half years and had had the usual treatment. Within twenty-four hours after the administration of penicillin had been begun, all the pain disappeared, and he was left with little more than some residual stiffness of his joints.

The question remains as to whether one has, for the first time, a drug which is effective against both syphilis and gonorrhea. If penicillin only masks the symptoms of syphilis and fails to eradicate the disease, one may be faced with a new problem. For example, a patient suffering from both gonorrhea and syphilis, contracted at the same time, might conceivably not be recognized as suffering from syphilis, owing to the action of penicillin in masking the disease.

Another feature worth mentioning concerns the cases in which the treatment has failed. Although patients sometimes failed to respond to a moderate dose of penicillin, when a second course of a similar dose was given they generally got well, furthermore, in cases of gonorrhea if failure was experienced after the first dose and the patients had already been found to be resistant to sulfonamide drugs, they appeared to get well if they were subsequently treated with sulfonamide compounds. It would not do to be too definite, but it is felt that gonorrhea can always be cured by the use of penicillin. With regard to syphilis, however, it remains to be seen whether or not such an optimistic verdict can be pronounced.

Sako, Tilbury and Colley⁴⁸ reported 16 cases in which children who had chronic gonorrheal vaginitis were treated by the intramuscular injection of a single dose of 100,000 units of penicillin. Clinical and bacteriologic cure was effected in 15 cases within three days, usually in two days. The remaining patient required further therapy with divided doses of penicillin. Because of its safety and rapid action, penicillin is the drug of choice for the treatment of chronic gonorrheal vaginitis in children. One dose of 100,000 units of penicillin, injected

48 Sako, W., Tilbury, R., and Colley, J. One Dose Penicillin Treatment of Chronic Gonorrheal Vaginitis in Children, *J. A. M. A.* **128**: 508-509 (June 16) 1945.

intramuscularly, seems adequate in most cases. Hospitalization is not necessary.

Schmidlapp, Bosworth and Riba⁴⁹ said that in approximately 98 per cent of cases in which gonorrhea is resistant to sulfonamide therapy the patients will respond satisfactorily to a total dose of 160,000 units of penicillin injected in doses of 10,000 units every three hours. Smaller doses will increase the percentage of cases in which the results of treatment may be classified as failures. Persistence or recurrence of the urethral discharge during the first ten days after the completion of treatment with penicillin is the most reliable sign that the treatment has failed. During the first seven days after the completion of treatment with 100,000 units of penicillin, bacterial cultures and examination of urethral smears are an unreliable indication of the results of the treatment. In a large number of cases, it is difficult to determine whether *N. gonorrhoeae* is present in urethral smears obtained after the completion of treatment. This seems to indicate that penicillin limits the growth and multiplication of *N. gonorrhoeae*. Many authors have minimized the importance of the presence of extracellular and extraepithelial gram-negative diplococci in urethral smears obtained after the completion of treatment with penicillin. Although many new drugs are available, gonorrhea still is difficult to cure. In a small percentage of cases local treatment is necessary.

Horn and Cowper⁵⁰ considered the use of sodium penicillin in the treatment of sulfonamide-resistant gonorrhea. The drug was administered to 71 women with gonorrhea. In all but 1 of these, the disease had been found to be resistant to sulfonamide drugs. In 21.6 per cent of the cases, sodium penicillin presumably failed to cure the gonorrhea. It is interesting to note the site of infection in the cases in which the result was a failure. Administration of sodium penicillin failed in 11.6 per cent of the cases in which the infection involved only the lower part of the genital tract and in 35.5 per cent of the cases in which the upper part of the genital tract also was involved. The percentage of failures was lower in cases in which the disease had been present for some time.

Administration of 100,000 units of penicillin presumably failed in 21.4 per cent of the 14 cases of sulfonamide-resistant gonorrhea in which the patients were men. No serious reaction to penicillin was observed in these cases.

49 Schmidlapp, C. J., Bosworth, N. L., and Riba, L. W. The Clinical Use of One Hundred Thousand Units of Penicillin in Sulfa-Resistant Gonorrhea, *Brit. J. Urol.* **16** 133-143 (Dec.) 1944.

50 Horn, P., and Cowper, H. H. Sodium Penicillin in the Treatment of Presumably Sulfonamide-Resistant Female Gonorrhea, *West J. Surg.* **53** 108-112 (April) 1945.

Early diagnosis and early institution of penicillin therapy are paramount considerations in the control of gonorrhea. In cases in which the patients are women, the diagnosis and cure are difficult and time consuming, and delay caused by a preliminary trial of the sulfonamide drugs may diminish the possibility of cure.

Reynolds and Weyrauch⁵¹ made a clinical study of 509 gonococcal and 26 nongonococcal infections of the urogenital tract treated with penicillin. When the drug was given intramuscularly in doses of 10,000 units every three hours, initial courses of 80,000 units or more produced a cure in more than 98 per cent of the cases of gonococcal infection, regardless of the extent of the urogenital lesion or its chronicity. The administration of 100,000 units was recommended for uncomplicated gonococcal infection and 160,000 units for infections with severe complications. In the experience of these authors, the administration of 100,000 units in five doses of 20,000 units each did not yield as satisfactory results as did the more prolonged schedule. Of the 21 patients who had gonorrheal infection and failed to respond to the first course of penicillin, 20 responded favorably to a second course and only 1 patient required a third course.

In most instances the resolution of gonorrheal arthritis was not accelerated by the use of penicillin, although the urogenital focus was eradicated promptly.

It is now firmly established that penicillin is the most potent drug so far developed for combating gonorrhea. Since it is so highly effective, it should supplant all other forms of chemotherapy in the treatment of gonorrheal infections of the urogenital tract. The advantages which penicillin bears over the sulfonamide drugs are overwhelming: it acts more rapidly and it is more uniformly successful, not only in cases of simple urethritis but also in cases of parenchymatous lesions, blindly ending accessory urethral channels and small periurethral abscesses which respond poorly, if at all, to sulfonamide compounds. It is as effective in the chronic lesions as in the acute processes, another point of superiority over the sulfonamide drugs, and it is completely nontoxic in doses far exceeding those required for therapeutic purposes. Its few points of inferiority are that at present penicillin lacks permanent stability and must be administered parenterally.

The role of penicillin in the treatment of nongonococcal urogenital infections is less impressive. The drug is useless against the colon bacillus, which accounts for a large proportion of urogenital infections. It has proved disappointing against the large group of nonspecific infec-

51 Reynolds, L. R., and Weyrauch, H. M. The Use of Penicillin in the Treatment of Urogenital Infections. A Clinical Study of Five Hundred and Nine Gonococcal and Twenty-Six Non-Gonococcal Infections of the Urogenital Tract, *J Urol* 53 614-629 (April) 1945.

tions of the urethra, prostate and epididymis. Apparently, the widest application is against the coccic infections, especially those of the kidney and perinephric space. In these cases its contribution may prove invaluable. Since the amount of penicillin required to kill staphylococci is considerably greater than that required to kill gonococci, much larger quantities of the drug are indicated.

Doolittle and Marshall⁵² reported that in a series of 294 cases of sulfonamide-resistant gonorrhea, 100 per cent of the patients were cured with penicillin. Of 246 patients treated with only 50,000 units, 95.5 per cent were cured. Of 48 patients treated with an initial course of 100,000 units, only 1 failed to obtain a cure. All patients in both groups were cured with a second course of 100,000 units.

UROLITHIASIS

Milbert and Gersh⁵³ said that the incidence of urolithiasis was high among soldiers. Of the first 100 patients who were admitted to the urologic section of the Borden General Hospital, 21 had evidence of calculi, an incidence of more than 20 per cent. Fifteen of the succeeding 80 patients had evidence of the disease. This preserved the ratio of 1 to 5.

Milbert and Gersh noted that calculous disease of the urinary tract appears to be present at a much earlier period of life than is generally believed. Of 54 patients with ureteral calculi, 35, or 64.8 per cent, were 20 to 30 years of age. Sixteen, or 29.6 per cent, were between 30 and 40 years. The average age of the entire group was 28.2 years. Of 27 patients with renal calculi, 14, or 51.8 per cent, were 20 to 30 years. Ten, or 37 per cent, were between 30 and 40 years. The average age of the group with renal calculi was 27 years.

Patients requiring orthopedic treatment frequently predominate in wartime casualties, and the ever present danger of calculus formation due to recumbency or to calcium-phosphorus imbalance with multiple or extensive oblique fractures must be guarded against constantly.

A less common cause of formation of calculi and one that may assume some degree of importance because of the presence of troops in Africa is infestation with *Bilharzia haematobia* (*Schistosoma haematobium*). Calculi are formed about nuclei of the ova, blood clots or papillomatous tissue created by the action of the ova.

An observation worthy of note was the significantly low incidence of urolithiasis among Negro troops. In only 2 of the 84 cases reported were the patients Negroes. Urethral calculi were present in those cases

52 Doolittle, L. H., and Marshall, H. B. Penicillin Treatment of Sulfonamide-Resistant Gonorrhea, *J Urol* **53** 634-637 (April) 1945.

53 Milbert, A. H., and Gersh, I. Urolithiasis in the Soldier, *J Urol* **53** 440-446 (March) 1945.

The findings of Milbert and Gersh are consistent with the observations of other authors. In World War I, only 52 instances of nephrolithiasis were recorded among 286,548 Negro troops. The incidence per thousand Negro troops was 0.18, in contrast with an incidence of 0.41 among white soldiers.

Keyser,⁵⁴ in discussing urolithiasis, stated that one must revert to the concept that calculus formation is one and only one of the many types of crystalline deposition, or lithiasis.

A region of degenerative change in the urinary epithelium is a *sine qua non* for calculus formation. This mucosal necrobiosis is usually situated in the collecting tubules of the pyramids in the wall of the ureter, in the bladder or in the prostatic tubules. In such regions, crystalline matter may be deposited. If it is walled off, the process is encapsulated and growth does not occur. However, if the crystalline deposit in a papilla or elsewhere becomes exposed through surface ulceration to the urinary stream, further crystalline deposition takes place at this site and grows until the mass breaks away into a calyx or the pelvis and a concrement ensues.

When there is such a calcific or crystalline deposition in tissue, hyperexcretion of crystalloids, as in hyperparathyroid disease, in gout or in sulfanilamide poisoning, affords an abundance of stone-forming material to be deposited thereupon and greatly enhances the chance of stone formation, as the solution mechanism of the urine is upset. Likewise, infection, especially with urea-splitting micro-organisms, will supply an excessive amount of insoluble crystalline matter to be deposited at such sites.

Stasis, the urinary p_H , the urinary concentration and the body temperature are factors which do not produce calculus themselves but are of the utmost importance in modifying the rate of growth of the stone. Also, they modify the composition, the shape and the size of the stones. Stasis may irritate the wall of the pelvis, ureter or bladder and satisfy conditions for stone formation.

Flocks⁵⁵ stated that certain conditions are definitely known to predispose to stone formation. This is especially true if immobilization of the patient takes place, if portions of the urinary tract are paralyzed and if obstruction and infection of the urinary tract occur as a result of trauma.

In a previous report based on chemical and clinical studies in 279 cases of calcium urolithiasis, Flocks suggested that (a) calcium urolithiasis occurs frequently in these conditions because of the associated hypercalcinuria, urinary infection and urinary stasis and (b) the

54 Keyser, L. D., in discussion on Flocks⁵⁵ and Milbert and Gersh,⁵³ p. 447.

55 Flocks, H. R. The Preventive Treatment of Calcium Urolithiasis. The Important Role of Early and Frequent Roentgenographic Examinations, *J. Urol.* 53: 427-439 (March) 1945.

mechanism of this phenomenon is much initial precipitation of calcium phosphate resulting in the formation of many small calculi in the first few weeks of recumbency and stasis

Further experience with cases of calcium urolithiasis serves to emphasize the importance of frequent and early roentgenographic check-up examinations whenever conditions predisposing to calcium urolithiasis are or have been present

The three fundamental causes of calcium urolithiasis are hypercalcinuria, urinary stasis and infection of the urinary tract. If recumbency is necessary, hypercalcinuria cannot be prevented. The only thing that can be done to counteract this is dilution of the urine by maintaining a large urinary output. Stasis of some degree cannot be avoided when damage of the central nervous system is present. Infection cannot be completely prevented if catheters and drainage tubes are necessary for adequate drainage of the urinary tract. Therefore, in spite of painstaking treatment, calcium stones may form.

The preventive treatment of calcium urolithiasis in patients who are immobilized consists essentially in six measures: the maintenance of a large fluid output, the control of diet, the control of urinary stasis, the control of infection, the continuation of treatment for three months after immobilization has been discontinued and frequent roentgenographic checkup examinations.

Early diagnosis, which is best made by frequent roentgenographic examination, is of considerable importance because such stones in their early stages are loose concretions which can in many cases be broken up and washed out or caused to pass before any extensive damage to the urinary tract has occurred and without the need of an open surgical procedure. It is important because the stones may be silent and produce no manifestations of their presence until they are large, coalescent masses and have produced extensive renal damage which may require an open surgical procedure for repair or may be so extensive that the damage is irreparable.

The method of roentgenologic examination usually used at the University Hospital consists of a plain roentgenogram and another one made twenty minutes after the intravenous injection of 20 cc of diodrast. The examination is made one month after the onset of the predisposing condition. If stones do occur or if other complications, such as infection of the urinary tract, occur, the roentgenographic examinations are made more frequently.

Harrison, Botsford and Pierce⁵⁶ stated that the problem of urinary calculi represents an important aspect of military medical practice in

56 Harrison, J H, Botsford, T W, and Pierce, F R. The Management of Urinary Lithiasis in an Army General Hospital, *J Urol* 53 282-294 (Feb) 1945

the tropics The soldier who has passed a calculus or who has been relieved by operative removal of a calculus should be instructed as to the importance of high fluid intake to prevent recurrence Adequate consumption of salt is important in the body's conservation of water in the tropics If practicable dietary measures should be instituted as prophylaxis against formation of calculi The patient having bilateral or recurrent renal lithiasis should not return to tropical service Persistence of infection or the presence of an obstructive congenital anomaly of the urinary tract is a contraindication to further tropical service Sixty-six of 100 consecutive patients who were admitted to the hospital because of urinary lithiasis were returned to and remained at full military duty, 9 were able to do limited duty, and 25 were returned to the United States Thirty-five patients were relieved of calculi as a result of cystoscopic manipulation, of 31 who required no operative intervention 15 passed calculi spontaneously Thirty-seven open operations were performed on the remaining 34 patients

UROGRAPHY

Pritchard,⁵⁷ in discussing intravenous urography, stated that the "standard" dose of intravenous dye is inadequate Two to three times the recommended quantity may be given to average adults, double this amount to children and three times this amount to infants To avoid confusion, the dose should be expressed in grams of iodine because of its varying percentage in the products used

The patient's preliminary concentrating power measures one essential renal function and forecasts the probable radiodensity of resulting urograms It permits individual modification of dosage for optimal density or decides against application of the method

Inefficiently concentrating kidneys usually produce dense urograms with sufficient dye Rarely, they produce more dilute urine and paler roentgenograms Some poorly concentrating kidneys show temporary displacement by the iodine molecules of other crystalloids More efficient kidneys do not show this but increase the specific gravity by addition of the heavy iodine molecules

The safety and almost universal applicability of excretory urography have been demonstrated

Draper and Siceluff⁵⁸ described a procedure for visualization of the bladder and urethra Five separate roentgenograms of the lower part of the urinary tract are made (1) an air cystogram is made, (2)

57 Pritchard, W Notes Regarding Intravenous Urograms, Based on Two Thousand Series in Eighteen Years, *J Urol* **53** 387-392 (Feb) 1945

58 Draper, J W, and Siceluff, J G Excretory Cysto-Urethrograms, *J Urol* **53** 539-544 (April) 1945

a urogram is made while the patient is voiding the contrast medium, (3) the patient is asked to stop voiding and a third urogram is made, (4) the next urogram is made while the patient is voiding against obstruction produced by a penis clamp, and (5) the patient is allowed to empty his bladder and a final urogram is made to demonstrate any residual urine which may be present

INJURY OF THE GENITOURINARY TRACT

Reynolds⁵⁹ stated that injuries of the urogenital tract in war present the same problems as those in civilian life. Injuries of the kidney require surgical intervention only when hemorrhage is extensive enough to demand control. In such cases, nephrectomy usually has to be done to assure hemostasis. Suprapubic puncture of the bladder to establish drainage is the procedure of choice in most cases of rupture of the urethra or vesical paralysis due to injury of the central nervous system. The present means of controlling shock and the efficiency of the urinary antiseptics available make it possible to save more patients with severe injuries to the urogenital tract than formerly was possible.

CHANCROID

Allison⁶⁰ stated that chancroid is a common venereal infection in women as well as in men although not so immediately or easily recognizable in women. Lesions may be recognized in practically all patients formerly designated as carriers. History of definite contact and subsequent culture will establish an accurate diagnosis. Search of stained smears will reveal the bipolar *Bacillus* of Ducrey. The Ducrey cutaneous test is helpful but not diagnostic alone. Venereal diseases frequently occur in multiples. In each case the examiner must ask not which but how many diseases the patient has. Other venereal diseases alter, accelerate and modify the progress and clinical characteristics of and the patient's reaction to a given single infection. Women tolerate chancroidal infection and are more resistant to the destructive lesions than are men. Sulfathiazole is especially valuable in the treatment of chancroid.

URINARY OBSTRUCTION

Riba and Schmidlapp⁶¹ stated that in the army urinary obstruction is a common lesion which most frequently involves the upper part of the

59 Reynolds, L. R. War Injuries to the Genito-Urinary Tract. A Brief Review of the Types of Injuries Observed in One U. S. Naval Base Hospital in the Pacific, *J Urol* **53** 419-421 (Feb.) 1945

60 Allison, G. G. Chancroid Disease in the Female, *J Urol* **53** 503-506 (March) 1945

61 Riba, L. W., and Schmidlapp, C. J. Surgical Treatment of Urinary Obstruction in Army General Hospitals, *Surg., Gynec. & Obst.* **80** 368-372 (April) 1945

ureter, vesical neck and urethra. In the majority of cases the lesions existed prior to the induction of the soldier into the service. The prostatic diseases of senescence are uncommon. Ample opportunity exists in the army to correct congenital obstructive lesions early with minimal morbidity and mortality. In maladjusted and inadequate patients in military service, operation for lesions which existed prior to induction, unless emergent, is usually contraindicated.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1944

A Review Prepared by an Editorial Board of the American Academy of
Orthopaedic Surgeons

XVIII Infections of Bones and Joints Exclusive of Tuberculosis

PREPARED BY LENOX D BAKER, M D, DURHAM, N C

AS HAS been true in all the years of the war, the literature for 1944 contained relatively few articles on osteomyelitis excepting those dealing primarily with reports of cases in which penicillin therapy and chemotherapy were used. When a new antibiotic is introduced there is always a flood of such reports, with few articles that rationalize the changes that are necessary to allow the new drug or procedure to take its proper place in the over-all picture of the disease under discussion. Certainly penicillin is a valuable adjunct in the treatment of osteomyelitis, and its presence makes necessary a reevaluation of previous ideas in regard to treatment of this disease. The antibiotic value of penicillin has been established. Studies are now needed to determine its side actions on the reticuloendothelial tissues, the hemopoietic system, the glands of internal secretion and the other factors associated with the response of the body to the administration of this organic substance.

Anderson, Howard and Rammelkamp⁶²² report a series of 40 cases of chronic osteomyelitis treated with penicillin. In 25 of the cases there was a follow-up of one year or more. The patients ranged in age from 14 to 74 years. Duration of the infection ranged from two months to forty-nine years. In 19 cases draining sinuses had been present a year or more. The drug was used intramuscularly, intravenously and locally. In 31 cases only one course of penicillin was given. The authors express the opinion that local therapy alone was not of material benefit but that when combined with systemic therapy it may be advantageous. The total dosage of the drug ranged from 400,000 units to 5,500,000 units. Duration of the treatment was from two to fifty-six days. Surgical treatment was used in 12 cases. Nine patients received a second course of penicillin therapy because of relapses. The status of the patients at the time of the report was as follows: infection arrested (no relapse) 23, spontaneous arrest after relapse 5, relapse (lesion draining) 4, improvement 2, no improvement 5, and

622 Anderson, D G, Howard, L. G, and Rammelkamp, C H. Penicillin in Treatment of Chronic Osteomyelitis. Report of Forty Cases, Arch Surg 49: 245-257 (Oct) 1944.

death 1 The authors conclude (1) that penicillin is the most effective chemotherapeutic agent for the treatment for staphylococcal infection and (2) that primary closure following sequestrectomy or evacuation of an abscess of a bone is a safe and satisfactory procedure for patients who are receiving penicillin

Ericksen ⁶²³ reports the use of penicillin in the treatment of a white man with osteomyelitis who had been given sulfadiazine and sulfathiazole for twenty-five days Cultures of the blood remained positive throughout the entire period Penicillin was started All cultures of the blood made after penicillin therapy was started were negative The temperature subsided, and the patient was discharged from the hospital at the end of two weeks, apparently cured of his infection

Mowlem ⁶²⁴ reports 20 cases of osteomyelitis of the mandible treated with penicillin, 16 of the patients had well established and gross infections Penicillin was used in conjunction with radical surgical treatment and primary closure followed by irrigation with penicillin Four of the cases were postoperative cases in which it was thought that penicillin contributed to a speedy and uncomplicated convalescence Mowlem reports 1 case, that of a soldier aged 53 with a draining sinus in the iliac crest One thousand units of penicillin were injected daily for ten days, with no change in the sinus or its bacterial flora At operation a sequestrum was found in a cavity lined with fibrous tissue The author concludes that penicillin will not give bacteriologic control in the presence of sequestrums and it is not a substitute for operation

Gaul ⁶²⁵ reports 6 cases of osteomyelitis in which penicillin was used

Pittman ⁶²⁶ reports on a patient treated nineteen days with sulfathiazole for osteomyelitis of the femur, without improvement On the nineteenth day treatment with penicillin was started Recovery was rapid, beginning on the third day after penicillin was started Pittman stated the belief that had the patient received penicillin earlier destruction of bone would have been prevented, surgical intervention would have been unnecessary and a shorter convalescence could have been expected

Riddell ⁶²⁷ reports a case of osteomyelitis in which dislocation of the hip was treated by penicillin

623 Ericksen, O C Staphylococcus Albus Osteomyelitis and Septicemia Treated with Penicillin, *J. A. M. A.* **124** 1053-1054 (April 8) 1944

624 Mowlem, R. Surgery and Penicillin in Mandibular Infection, *Brit. M. J.* **1** 517-519 (April 15) 1944

625 Gaul, J S Treatment of Six Cases of Osteomyelitis with Penicillin *Bull. Charlotte Mem. Hosp.* **1** 28-30 (March) 1944

626 Pittman, M A Penicillin in Treatment of Osteomyelitis and Other Infections Case Report, *Virginia M. Monthly* **71** 66-70 (Feb.) 1944

627 Riddell, T Penicillin in Acute Osteomyelitis Report of Case, *Nebraska M. J.* **29** 284 (Sept.) 1944

Robertson⁶²⁸ reports 34 cases of osteomyelitis in which penicillin was used, 9 patients received the drug systemically and 25 received it locally. Of the 9 patients treated systemically, 7 were children with acute osteomyelitis. The results were most satisfactory. The systemic therapy in 2 cases of chronic infection was of only temporary benefit. Local applications of penicillin in cases of chronic bone sepsis proved disappointing. The author concludes that sequestrums and foreign bodies must be removed or the sinuses will not heal.

Schaff and Ivey⁶²⁹ review penicillin therapy for osteomyelitis.

Kenney⁶³⁰ reviews the literature on acute osteomyelitis and compares the results reported before and after the introduction of the sulfonamide compounds. The average mortality rate without chemotherapy was 23 per cent. The mortality rate with chemotherapy averaged 3.5 per cent. The author compares the local results with and without chemotherapy and concludes that the sulfonamide drugs have not proved of value so far as the local pathologic process is concerned.

Key⁶³¹ discusses the use of the sulfonamide drugs in chronic osteomyelitis and reports 101 cases in which the patients had been given sulfathiazole for five days preceding surgical treatment. At operation, all infected soft tissue, dead bone and sequestrums were excised. The wound was dusted with sulfathiazole powder and closed, as recommended by Dickson, Dively and Keene, who had reported 82 per cent primary healing in a similar series. Sulfathiazole was administered orally for fifteen days after operation. Wounds in 60 cases healed by primary intention. The 101 cases in this series were not a selected group as were the cases reported by Dickson, Dively and Keene. The author concludes that this method of treatment should be used in all chronic pyogenic bone infections.

Baker, Schaubel and Kuhn⁶³² report a series of cases, with controls, in which they compare the end results of the treatment of acute osteomyelitis with sulfathiazole, sulfadiazine or sulfathiazole and sulfadiazine, with and without operation. They studied 56 cases, in 30 of which patients were treated with surgical drainage, when last seen 21 patients

628 Robertson, I. M. Penicillin in Bone Infections, *Brit. M. J.* **1** 519-521 (April 15) 1944.

629 Schaff, B., and Ivey, H. T. Penicillin in Treatment of Osteomyelitis, *M. Bull. Vet. Admin.* **20** 369-372 (April) 1944.

630 Kenney, W. E. Prognosis in Acute Hematogenous Osteomyelitis With and Without Chemotherapy, *Surgery* **16** 477-484 (Oct.) 1944.

631 Key, J. A. Sulfonamides in the Treatment of Chronic Osteomyelitis, *J. Bone & Joint Surg.* **26** 63-70 (Jan.) 1944.

632 Baker, L. D., Schaubel, H. J., and Kuhn, H. H. Open Versus Closed Treatment of Acute Osteomyelitis. Clinical Report on Use of Antitoxin and Sulfonamide Drugs With and Without Early Drainage, *J. Bone & Joint Surg.* **26** 345-349 (April) 1944.

in this group had active draining sinuses and 9 had healed lesions. Twenty-six of the patients were treated by aspiration, when last seen 21 of the 26 had sinuses that never drain and in 4 sinuses that drained spontaneously. All 56 patients were treated with sulfathiazole, sulfadiazine or sulfathiazole and sulfadiazine. They all had the same supportive care, the only difference in the therapy being in the use of surgical drainage and the use of aspiration.

These authors list the standing orders at Duke Hospital for patients admitted with a diagnosis of acute osteomyelitis as follows:

- 1 A complete examination, including roentgenograms of the parts affected and flat plates of the chest, is to be made, additional roentgenograms to be taken as indicated.

- 2 Hemoglobin determination, and red-blood-cell and white-blood-cell counts are to be done, the latter to be a differential count to estimate the relative percentage of mature and immature polymorphonuclear cells. The hemoglobin and differential white-blood-cell count are to be repeated daily for the first week, then every other day during the acute stage of the disease.

- 3 Adequate doses of staphylococcus antitoxin are to be given, if the white count indicates that the patient is not producing sufficient antitoxin to combat the toxæmia.

- 4 Sulfathiazole or sulfadiazine is to be given, the amount to be determined according to dosage chart. (Until recently the dosage of the sulfonamide drugs was fairly well established, and it was felt that a dose sufficient to maintain a blood level of four to eight milligrams per 100 cubic centimeters was ample. It may be, however, that this level is too low. Robertson has used larger doses of the drugs—four to six grains per pound of body weight per day—without undue signs of toxic effect from the drugs, and, apparently, with earlier control of the disease than is seen with the smaller doses.)

- 5 Daily urine examinations are to be made for the first week and then every other day as long as the sulfonamides are given. (The first urine examination is made immediately upon admission, as the patient may have had large amounts of a sulfonamide before admission.)

- 6 Sufficient intravenous fluids are to be given in the form of physiological solution of sodium chloride, with 5 per cent to 10 per cent glucose, to combat dehydration and to supply the needed chlorides and carbohydrates.

- 7 The patient's blood is to be matched for blood transfusion, and transfusions of 150 to 200 cubic centimeters are to be given daily or as indicated.

- 8 A staphylococcus titer is to be done on admission and following transfusion from each new donor. A staphylococcus titer is also done on all donors.

- 9 Blood cultures are to be planted on admission and daily thereafter, or until the cultures have been negative on three successive days.

- 10 Sedative is to be given as indicated to keep the patient comfortable and at rest.

- 11 Violet-ray therapy is to be given daily after the patient is well enough to be transported to the Physical Therapy Department.

- 12 The affected part is to be put at rest in the best position for function. Traction, splints, or cast should be used to suit each case.

13 Normal saline compresses are to be applied to the involved area or areas

14 Abscesses are to be aspirated and cultured Following aspiration, the abscess is to be gently irrigated with sterile normal saline solution until the washings are clear One or two grams of microcrystal solution of sulfathiazole is to be instilled with the last washing, and the abscess is then to be re-aspirated as completely as possible. Additional irrigations and local instillation of sulfathiazole are to be done as indicated.

15 The patient is to be put on a high-vitamin diet as early as possible.

16 Accessory vitamins are to be given (intravenously if necessary) as follows (dosage for a child ten years of age or older, smaller dosage for younger patients)

Ascorbic acid, fifty milligrams three times a day,

Thiamine chloride, five milligrams three times a day,

Nicotinic acid, twenty-five milligrams twice a day (preferably the amid form to avoid flushing)

Oleum percomorphum ten drops twice a day (cod-liver oil is preferable if the patient can tolerate it)

They discuss the use of accessory vitamins as follows

It is well established that a patient with an infectious disease may rapidly become deficient in vitamin C and that he requires larger amounts of the vitamin to keep saturated. Also, it has been shown that new capillaries fail to form in fibrin clot in the absence of sufficient vitamin C These facts make the giving of an ample dose of ascorbic acid so important to osteomyelitic patients Vitamin A must be supplied if epithelialization is to take place, and vitamin D is necessary for the bone repair The various B vitamins are essential as stimulators of the appetite and as aids in the patient's general well-being

Sixteen of the patients gave a history of having had sulfonamide therapy before their admission to the hospital Of the 16 patients, 3 had positive cultures of the blood and 13 had negative cultures Of the 3 who had positive cultures, 1 had received a sulfonamide drug for one day and 1 for three days One had received sulfanilamide for eight days (It is known that sulfanilamide is contraindicated in staphylococcal infections) Twenty-two of the patients had received no sulfonamide therapy before admission Sixteen of these had positive cultures of the blood, and 6 had negative cultures There was no record as to sulfonamide therapy before admission on 10 of the patients Six had positive cultures of the blood, and 4 had negative cultures The authors do not include patients treated with penicillin therapy but state, "Penicillin, another bacteriostatic substance, has been found to be effective in combatting the staphylococcus, but until penicillin or a like substance has become available, sulfathiazole, sulfadiazine, or both are our best bacteriostatic drugs" (The authors are now using penicillin) The paper lists the following conclusions

1 A well-planned, useful, supportive routine is necessary for osteomyelitic patients

2 Staphylococcus toxins can be neutralized *in vivo* by antitoxin prepared from Burky's Ha strain of hemolytic staphylococcus aureus

3 The mortality rate in hemolytic staphylococcus aureus osteomyelitis can be lowered by the use of sulfathiazole, sulfadiazine, or both

4 The morbidity of the disease can be reduced if surgical drainage is not used

Meyerding⁶³³ discusses sclerosing osteitis as one of the inflammatory diseases which must be considered in the differential diagnosis of benign and malignant lesions of bone. The paper quotes Garre's original description of the process and then discusses the acute stage of sclerosing osteitis and the chronic stage. In the differential diagnosis must be considered syphilis, sarcoma, Paget's disease, ossifying hematoma, osteitis fibrosa cystica, Ewing's sarcoma and metastatic carcinoma. Meyerding states the belief that the treatment is surgical and that saucerization is preferable to drilling or other procedures. [ED NOTE (L D B) — This is an excellent discussion of sclerosing osteitis, and if for no other reason except to get the points in the differential diagnosis the article should be read *in toto*]

Siler⁶³⁴ discusses the management of infections of the upper extremities. He points out the value of early and adequate incision and drainage, the use of sterile technic, including the wearing of a mask when dressing the wounds, and states that a good functional result and not just a nicely healed wound is the ideal goal.

In an article which was not available for review,⁶³⁵ Gierc reports on the action of beer yeast on staphylococcic infections.

Cutait and Musa,⁶³⁶ in another article which was not available for review, report the use of refrigeration anesthesia in therapy for osteomyelitis.

Chavez,⁶³⁷ in still another article not available for review, discusses the use of the inductotherm in the treatment of osteomyelitis.

Frank⁶³⁸ reports the case of a 43 year old white man in whom as a sequel of a staphylococcic infection of a finger metastatic lesions developed, including acute osteomyelitis of the odontoid process with a pathologic fracture. Frank discusses the differential diagnosis of osteomyelitis of the vertebrae and reviews the literature. The article by

633 Meyerding, H W. Chronic Sclerosing Osteitis (Sclerosing Non-Suppurative Osteomyelitis of Garre). Differential Diagnosis, S Clin North America **24** 762-779 (Aug) 1944

634 Siler, V E. Management of Injuries and Infections of the Upper Extremities, J A M A **124** 408-412 (Feb 12) 1944

635 Gierc, B. Action of Beer Yeast on Staphylococcic Infections. Use in Chronic Osteomyelitis, Rev med de la Suisse Rom **63** 788-794 (Oct. 25) 1943

636 Cutait, D E, and dos Santos Musa, F. Refrigeration Anesthesia in Osteomyelitis, Resenha clin-cient **13** 279 (July 1) 1944

637 Chavez, N. Treatment of Osteomyelitis by Inductothermy, Bol med d. Hosp inf, Mexico **1** 31-40 (July-Aug) 1944

638 Frank, T J F. Osteomyelitis of Odontoid Process of Axis (Dens of Epistropheus), M J Australia **1** 198-201 (March 4) 1944

Makins and Abbott is recommended as an excellent paper on the subject, it was published in the *Annals of Surgery* (23. 510, 1896)

Arden and Derrick⁶³⁹ report a case of osteomyelitis of the odontoid process of the axis

Neuhof and Arnheim⁶⁴⁰ present a comprehensive consideration of infections of the retroperitoneal tissues and list a clinical classification, dividing the cases as to localized form and as to diffuse form. Under the localized form they list the following types of abscesses: (1) lumbar, (2) iliac, (3) subphrenic only and (4) pelvic only. This classification is discussed according to (1) anatomy, (2) pathogenesis, (3) pathology, (4) bacteriology, (5) clinical manifestations, (6) diagnosis and (7) treatment and results. Brief reports of cases include 25 cases of lumbar abscesses, 23 of iliac abscesses and 17 of diffuse infections. The difficulty of accurate diagnosis is mentioned, and examination with the patient under anesthesia to allow accurate palpation without interference from protective muscle spasm is recommended. In only 25 per cent of their cases did symptoms suggest retroperitoneal abscess. [ED NOTE (L D B) —This is a good discussion of an interesting subject. The paper warrants a full study.]

Raventós Moragas,⁶⁴¹ in a paper not available for review, reports a case of primary osteomyelitis of the patella.

Rountree⁶⁴² made a survey of all cases of osteomyelitis seen in the University of Oklahoma School of Medicine and Crippled Children's Hospital and found 714 patients with osteomyelitis admitted from 1931 to 1939. Of this group, 5 per cent showed osteomyelitis of the fibula only (36 cases). Rountree discusses diaphysectomy for chronic osteomyelitis of the fibula. He does not advocate the procedure for osteomyelitis of other long bones nor does he recommend the procedure for osteomyelitis of the fibula in the acute stage. There is a detailed account of his operative procedure and the use of a long rubber drain which is laid in the bed of the resected fibula, with the periosteum closed over it. The drain protrudes from the lower pole of the incision and is gradually removed over a period of ten days to two weeks. The results in 31 patients with a follow-up of from nine months to eight years were as follows: Concerning growth changes, no deformity of the knee or ankle developed. Regeneration of the fibula was complete in 13 cases, incomplete in 8 cases, slight in 3 cases and absent in 7 cases (4 of the

639 Arden, F, and Derrick, E. H. Osteomyelitis of Odontoid Process of Axis. Case, M. J. Australia **2** 487-488 (Nov 4) 1944.

640 Neuhof, H, and Arnheim, E. E. Acute Retroperitoneal Abscess and Phlegmon. Study of Sixty-Five Cases, Ann. Surg. **119** 741-758 (May) 1944.

641 Raventós Moragas, A. Primary Osteomyelitis of Patella. Case, Rev. clin. españ. **12** 316-320 (March 15) 1944.

642 Rountree, C. R. Diaphysectomy for Chronic Osteomyelitis of the Fibula, Clinics **2** 1040-1054 (Dec) 1943.

7 patients were adults) Functional results were satisfactory in all but 3 patients, and these showed some improvement One case was complicated by pyarthrosis of the ankle In no instance had there been a recurrence of the osteomyelitis [ED NOTE (L D B) —This is an excellent paper]

The 1944 literature contained four papers that were available for review which discussed infections in bones other than tuberculosis or staphylococcic infections

Lubert⁶⁴³ discusses actinomycosis infection of the vertebrae and reports 3 cases, with autopsy and roentgenologic findings He points out that poor oral hygiene, dental extractions or tonsillectomies may be followed by such infection He is of the opinion that the vertebrae are involved secondarily, usually by direct extension or occasionally by infection of the blood stream The disease process is a chronic granuloma, and roentgenograms usually show areas of destruction in all portions of the vertebrae, including the spinous processes and lamina as well as the bodies, with varying amounts of surrounding sclerosis, without roentgenologic evidence of destruction of intervertebral disks In contradistinction to tuberculosis, collapse of a vertebra despite extensive destruction is unusual

Colonna and Gucker⁶⁴⁴ report a case of blastomycosis of the bone and summarize 67 recorded cases from the literature In the 67 recorded cases the skeletal lesions were almost commonly found in the following locations in the order given (a) vertebrae, (b) skull, (c) ribs, (d) tibia, (e) tarsus, (f) knee, (g) metatarsus and (h) carpus Infections are usually found in patients with generalized blastomycosis The mortality rate in cases of skeletal blastomycosis is 89 per cent, only 7 recoveries being reported in the 67 recorded cases Diagnosis is made by isolation and identification of the fungus Tentative diagnosis can be made by complement fixation test and skin test Roentgenograms of the chest may be indicative The roentgenologic appearance is not pathognomonic, however, definite observations are important The lesion usually has a patchy appearance, with local destruction and a homogenous periosteal sheath Treatment recorded in the literature includes a high caloric, high vitamin diet, heliotherapy, blastomyces vaccine, immune serum, neoarsphenamine, antimony, potassium tartrate and potassium iodide All 7 patients reported as having survived had received a saturated solution of potassium iodide orally Local treatment has consisted in irrigations and the use of maggots In the

643 Lubert, M Actinomycosis of the Vertebrae, *Am J Roentgenol* **51** 669-676 (June) 1944

644 Colonna, P C, and Gucker, T, III Blastomycosis of Skeletal System Summary of Sixty-Seven Recorded Cases and Case Report, *J Bone & Joint Surg* **26** 322-328 (April) 1944

case reported, sulfadiazine was used along with potassium iodide, blood transfusions and good supportive care. The patient died four months after his admission to the hospital. Permission for autopsy was not obtained. The areas involved were as follows: knees, elbows, humeri and carpal bones. [ED NOTE—It has been my privilege to observe the work of Smith, Martin, Jones and Conant, whose papers are included in Colonna's and Gucker's bibliography. It is the opinion of these workers that in the treatment of blastomycosis infections it is most important that the patient be desensitized before operation is attempted or before treatment with potassium iodide is instituted. They feel that this desensitization will prevent reactions and will help control flare-ups of the infection.]

Chunard,⁶⁴⁵ in an article not available for review, discusses the orthopedic aspects of brucellosis.

Brown and Gottdiener⁶⁴⁶ report a case of a white man, aged 21, seen in consultation in regard to a painful shoulder of twelve hours' duration. Examination showed tenderness about the right shoulder. Twelve hours after admission the patient became stuporous and the temperature rose to 102 F. The white blood cell count was 26,700. Lumbar puncture showed 15,000 cells per cubic centimeter, of which 98 per cent were polymorphonuclear cells. A smear revealed gram-negative intracellular and extracellular diplococci. A culture grew out type 1 meningococci. The patient was treated with sulfadiazine and improvement was progressive, the petechial rash over the body disappeared, but rash over both tibias coalesced into a large hemorrhagic area, which was tender. This area of discoloration disappeared slowly over a period of three weeks, but the tenderness remained over the tibias. Roentgenograms of the tibias eighteen days after the patients' admission to the hospital showed irregular cortex, with rarefaction and spotty periosteal elevation. Roentgenograms three months later showed a normal condition except for slight thickening of the anterior cortices. The authors were of the opinion that the changes shown in the tibias were those of localized confluent hemorrhage into the skin and subcutaneous tissues, depriving the periosteum of blood supply, thus diminishing the nutrition of the cortex below.

Pierson and Roach⁶⁴⁷ discuss the roentgenologic changes seen with acute hemorrhagic osteomyelitis and point out the pathologic basis for the roentgenologic changes.

645 Chunard, E. G. Orthopaedic Aspects of Brucellosis, Northwest Med 43 279-283 (Oct.) 1944

646 Brown, M. G., and Gottdiener, E. E. Osteoperiostitis Following Meningococcus Meningitis. Case Report, Mil Surgeon 94 270-271 (May) 1944

647 Pierson, J. W., and Roach, J. F. Roentgenology of Osteomyelitis, J A M A 126 884-886 (Dec 2) 1944

Silver and Rushbridge⁶⁴⁸ report the use of a saturated iodoform-benzoin solution to counteract the odor of plaster-encased war wounds. The mixture consists of 3 cc of iodoform and 240 cc of tincture of benzoin compound, painted over the exterior of the offending area of the cast. The authors state that the solution is readily absorbed by the cast and that the resulting odor is relatively agreeable.

Regan and Henderson⁶⁴⁹ report the use of wool impregnated with activated charcoal to counteract odors from plaster-encased wounds, the wool being in the form of a bag. The bag is drawn over the plaster cast. Another method of using the material is in the form of small wool dressings impregnated with the charcoal, which are placed directly over the wound dressing through a cast window. The authors report satisfactory elimination of offensive odors with this method. They refer to the work of Seddon and Florey.

Lambert and Stickney⁶⁵⁰ report the use of plaster bandages containing selected activated carbon in an attempt to minimize the odor of plaster in the case of osteomyelitis. This type of plaster roll is now on the market.

XIX. Fracture Deformities

PREPARED BY EUGENE M. REGEN, M.D., NASHVILLE, TENN. PAUL HARMON, M.D.,
HUNTINGTON, W. VA., AND GLENN BARBER, M.D., CLEVELAND

FEWER papers were published on fracture deformities in 1944 than in any year since this section of the progress in orthopedic surgery has been written.

Murray⁶⁵¹ has summarized, in outline form, the essentials for success in bone grafting in ununited compound fractures. In order to obtain a "take" of a bone graft in compound fractures, (1) the graft must unite and become an integral portion of the host bone, (2) new bone must form in response to function demands, (3) length and alignment must be preserved during the period preceding grafting or restored at the time of grafting and maintained postoperatively and (4) both active and potential infection must be controlled. Murray discusses the mechanism of new bone formation and the known facts concerning its source as applied to a bed which has been previously infected. It is Murray's opinion that the type of graft is frequently not so important as is the

648 Silver, C. M., and Rushbridge, H. W. Use of Saturated Iodoform Benzoin Solution to Counteract the Odor of Plaster-Encased War Wounds. *Case, Mil Surgeon* **95** 233 (Sept.) 1944.

649 Regan, J. M., and Henderson, M. S. Charcoal Wool Filter Cloth as Deodorant. *Proc. Staff Meet., Mayo Clin* **19** 268-270 (May 31) 1944.

650 Lambert, C. N., and Stickney, D. W. New Deodorizing Plaster Bandage. *J. Bone & Joint Surg* **26** 836-837 (Oct.) 1944.

651 Murray, C. R. Basic Problems in Bone Grafting for Ununited Compound Fractures. *J. Bone & Joint Surg* **26** 437-442 (July) 1944.

proper preparation of the field to receive the graft and the host's tissues to maintain it. Specifically, these conditions are met by the following steps, which may be indicated prior to operation: (1) systemic attack on infection by attention to anemia, nutrition and systemic use of chemotherapy, (2) local attack on active infection by drainage, removal of dead bone and other foreign bodies and local chemotherapy, (3) allowing of sufficient time to elapse between control of infection and complete healing of the wound prior to bone grafting, (4) continued attention to the systemic status of the patient by estimation of hemoglobin and serum proteins and maintenance of nutrition, including vitamins, (5) utilization of plastic procedures after control of infection and prior to bone grafting, in order to supply a covering of healthy skin and subcutaneous tissues and (6) improvement of the efficiency of the local circulation, by exercise and active use, physical therapy, pressure dressings and supports, positional exercises (for example, Buerger exercises) and use of the extremity against gravity. The use of an extremity suitably braced is the most valuable single procedure to fulfil the latter need.

At operation the following basic steps must be taken: (1) removal of scar tissue from between and about the bone fragments and drilling or resection of sclerotic dense bone down to healthy bone, (2) plastic operations on the soft parts, (3) placing of a graft of adequate size in a bed where it can be most easily vascularized by newly formed connective tissue and (4) rigid fixation of the graft and the fracture fragments. The details of rigid fixation are unimportant, providing the condition is secured. The methods of rigid fixation are internal fixation of the graft, external fixation by plaster, pin and plaster, pin and apparatus or combinations of internal and external fixations. Local and systemic care must be continued in the convalescence.

Goff⁶⁵² reports the use of os purum, a substitute for the autogenous implant, in eighty bone-grafting operations performed on 61 patients.

The material was used for spinal fusion in 28 cases, as a peg for fixation in cancellous bone in 9 cases, as a posterior bone for foot drop in 10 cases, as a graft fixation after osteotomy in 8 cases, as a shelf for congenital dislocation of the hip in 7 cases and for obliteration of cranial defects in 2 cases.

In 9 of the 80 instances of operative procedure, the os purum implant had to be partially or entirely removed, for various reasons. Complications occurred in 16 instances being attributed directly to the os purum implant in 6.

Goff states that all complications totaled 20 per cent, with none constituting a major factor in the end result. Nevertheless he stated the

652 Goff, C. W. The Os Purum Implant. A Substitute for the Autogenous Implant. *J. Bone & Joint Surg.* **26** 758-767 (Oct.) 1944.

belief that the use of os purum has its place and constitutes a satisfactory material for the orthopedic surgeon

The only inkling the author affords the reader relative to the composition of os purum is given in two or three sentences at the end of the article. Here it is stated that for the duration of the war it appears that os purum cannot be obtained from Sweden, that the supply in this country is nearly exhausted and that perhaps some biochemical manufacturer may see fit to procure os purum in this country, if this can be done under trade agreements

In a memorandum on the healing of war fractures prepared by the subcommittee of the M R C War Wounds Committee,⁶⁵³ it is noted that, while delayed union is by no means uncommon, nonunion is comparatively rare, and it should even be rarer except in cases in which there has been gross loss of bone. Nonunion is generally avoidable if reasonable apposition of fragments is secured and uninterrupted immobilization is maintained sufficiently long.

It is noted that of the possible causes of delayed union some are subject to the control of the surgeon while others are not. Of the latter, three causes are listed. The causes controllable—to a greater or lesser extent—by the surgeon are more numerous and of greater importance. Ten are given, and each is discussed under a subheading.

LeCocq and Gilman⁶⁵⁴ state the belief that ununited fracture of the clavicle is more common than is generally supposed. They encountered 4 cases during eighteen months of service in naval hospitals. They report a single case, in which there was considerable overriding and deformity. The patient was treated by open operation, exuberant callus and fibrous tissue being removed and the ends of the bones drilled. Good fixation and stability of the fracture were then obtained with a four-holed vitallium plate. Immobilization was in a Sayre type of dressing of muslin for twelve days and then intermittently in a sling. Union was present in six weeks, and the patient had a full functional recovery, with no disability at the shoulder. [ED NOTE (E M R) —It should be noted that this was an instance of nonunion of only a few months' duration, and it is probable that in established nonunion with loss of bone of years' duration this simple method with relatively little post-operative immobilization would not be successful.]

Rothberg⁶⁵⁵ reported a case of fracture of the greater tuberosity of the humerus, with minimal displacement of the tuberosity fragment and

653 The Causes and Prevention of Delayed Union of Fractures, (Sub-Committee on Healing of War Fractures of M R C War Wounds Committee) Bull War Med 4 559-561 (June) 1944

654 LeCocq, E A, and Gilman P K, Jr. Ununited Fracture of Clavicle. Report of Case, U S Nav M Bull 42 1166-1167 (May) 1944

655 Rothberg, A S. Post-traumatic Defect of the Humeral Head, Am J Surg 65 293-294 (Aug) 1944

without dislocation of the humeral head, treated for three weeks by retentive dressings, followed subsequently by active and passive motion. The patient continued to complain of pain in the shoulder, although he continued to gain motion. A roentgenogram made three and one-half months after the injury showed a V-shaped area of bone absorption in the region of the greater tuberosity. Further treatment was by physical therapy and sling for one additional month. At six and one-half months, the patient had a complete range of painless motion (apparently no roentgenogram was made at this time). The author arrived at no definite conclusion as to the cause of the absorption. He compared this defect with the "groove defect," which is seen with regularity and which is part of the pathologic process in recurrent dislocation of the shoulder.

Mandl⁶⁵⁶ reports 2 cases of comminuted fracture of the elbow, seen late, at a time when there was ankylosis of the joint proper but a pseudarthrosis in the lower third of the humerus, 2 inches (5 cm) above the joint. A nearthrosis was produced from the pseudarthrosis by smoothing off projecting osseous spicules and inserting fascia lata about the end of the humerus. In the 2 cases motion, both active and passive, increased from a few degrees to 100 degrees in one case and to 60 degrees in the other, as evaluated three years and one year respectively after surgical attack. One patient worked successfully as a police officer and the other as a blacksmith. Neither complained of pain. Slight instability in lateral planes was present in extension with muscles relaxed. [ED NOTE—Roentgenographic reproductions accompanying the article showed progressive sclerosis of the bone ends with increased use. Judging from the descriptions and photographs in the article, the function of such a joint resembles that of an elbow that has been subjected to resection.]

Hamada⁶⁵⁷ reports a case of nonunion of a fracture of the lower end of the radius, an exceedingly rare condition. He quotes Watson-Jones as having found but 1 case of nonunion of this fracture out of 3,199 cases of Colles' fracture. The case reported demonstrated shortening of the forearm and pronounced radial deviation of the hand. Hamada treated his patient by a full thickness onlay extra-articular graft. Illustrations accompanying the article showed the appearance of the wrist in roentgenograms over a four year period, the latest being the end result. As an intermediate step, the extra-articular bridge of bone extending from the carpal region to the dorsum of the third metacarpal was removed (six months after the first operation). Four years after

656 Mandl F. Nearthrosis Following Comminuted Fracture of Elbow Joint, *J Internat Coll Surgeons* 7 362-364 (Sept.-Oct.) 1944

657 Hamada, G. Extra-Articular Graft for Nonunion in Colles's Fracture, *J Bone & Joint Surg* 26 833-835 (Oct.) 1944

operation, the patient had 40 degrees of flexion and 35 degrees of extension, with a good grip but incomplete flexion of the fingers. The roentgenogram showed that the onlay graft had consolidated into a fairly wide but distorted distal radius. Union had occurred with the distal fragment. There was a fairly large dorsal projection of the graft over the proximal carpus, but this configuration appeared to be essential for the stability of the wrist. This is a good example of utilization of a graft for temporary fixation for alinement of the carpus and metacarpus as well as the proximal radial fragment and the ununited fragment, the carpus and metacarpals later being freed by excision of the distal portion of the graft.

Velasco and Cal⁶⁵⁸ reported studies of 113 cases of fracture of the carpal scaphoid, with patients in 79 cases treated by the authors. The cause of pseudarthrosis of the carpal scaphoid is discussed. Pseudarthrosis developed in 16 per cent of their recent cases and in 42 per cent of their older cases. They recommend conservative treatment in recent cases. If roentgenologic examination at the end of three months does not show bony union but does indicate that healing is progressing, another six months of conservative treatment may be tried. If after three months of conservative treatment by immobilization the roentgenograms fail to show any signs of bony repair, bone grafting is indicated. In older patients with pseudarthrosis but no serious arthritis bone grafts may be used with good results. If pseudarthrosis is not complete, prolonged immobilization may promote bony union if immobilization has not been tried before. If immobilization has been tried, immediate grafting is indicated. Beck drilling failed in the authors' hands. In the cases of fracture with pronounced displacement and irreducibility, excision is indicated.

Burns and Michaelis⁶⁵⁹ report 26 cases in which a sliding bone graft was used for ununited fracture of the tibia. The grafts were fixed in position with vitallium screws. They report but one failure in their series.

In their report the statement is made that "In none of our patients was the fibula ununited, and when it was keeping the ends apart, it was either fractured or divided so as to allow the necessary contact to be made (8 cases)."

[ED NOTE (E M R) —The last statement is of interest because there have appeared in the recent literature two articles which were primarily concerned with the influence of an intact or early united fibula as a cause of nonunion in the tibia.]

658 Velasco, R. N., and Cal, G. Pseudarthrosis of Carpal Scaphoid Bone. Prevention and Therapy, *Bol y trab, Soc argent de cirujanos* 4: 777-790, 1943.

659 Burns, B. H., and Michaelis, L. S. Sliding Graft for Ununited Fractures of the Tibia, *Lancet* 1: 337-338 (March 11) 1944.

Albert⁶⁶⁰ reviewed 395 cases of fracture of the tibia and fibula in adults, to see whether some of the views recently put forward concerning the cause of delayed union in these fractures could be sustained

The time and stage or degree of union were given on clinical grounds or proved roentgenographic consolidation. On this basis the time of clinical union (in weeks) is plotted against the number of cases in twenty-three graphs illustrating the various factors considered in the analysis. Twenty weeks was taken as the dividing line between normal and delayed union. On this assumption union in 282 cases, or 71 per cent, was normal and in 113 cases, or 29 per cent, delayed.

The important conclusions expressed by the author as a result of his analysis are

- 1 There has been an increase in the incidence of delayed union during this war
- 2 This is noticed mainly in the newly established clinics
- 3 The increase is noticed in both simple and compound fractures
- 4 In the greater number of compound fractures, "disturbance" of the course of treatment and the use of continuous skeletal traction appear to be the chief factors causing this increase

Truog⁶⁶¹ reported 7 cases in which "ring" sequestrums developed in the tibia after the use of Steinman pins (6 cases) and Kirschner wires (1 case) as fixed traction for fractures. The pins and wires were incorporated in plaster. A positive culture for *Staphylococcus aureus* was obtained in 1 case, and there was copious discharge in the others (no mention was made of bacterial cultures in the other 6 cases). In 5 of the 7 cases sequestrectomy was performed, following which there was more or less prompt healing. Two of the patients did not have sequestrectomy performed and still had draining sinuses at the time the paper was written. The author recommended that skeletal traction be removed as soon as roentgenograms show "ring" sequestrum. Subsequent treatment should be sequestrectomy. Truog's opinion was that the causation was probably pressure necrosis plus a low grade infection. The possibility that these lesions might be the products of thermal necrosis produced by too rapid and vigorous insertion of the pins was not mentioned.

A brief history of bone drilling to promote osteogenesis in nonunion and delayed union of fractures is given by Pusitz and Davis⁶⁶²

⁶⁶⁰ Albert M. Delayed Union in Fractures of Tibia and Fibula, *J Bone & Joint Surg* **26** 566-578 (July) 1944

⁶⁶¹ Truog C P. "Ring" Sequestra as Complication of Fixed Skeletal Traction, *Am J Roentgenol* **52** 64-69 (July) 1944

⁶⁶² Pusitz, M E., and Davis, E. V. Bone-Drilling in Delayed Union of Fractures *J Bone & Joint Surg* **26** 560-565 (July) 1944

They state that bone drilling is not a method of choice in the treatment of definite nonunion. They enumerate three essential types of nonunion, namely, (1) typical pseudarthrosis, with sclerosis of the ends of the fragments, (2) fibrinous union with osteoporosis of the fragments and (3) fibrinous union with atrophy of disuse. They point out that although there may be no discernible callus in delayed union there is no sclerosis of the ends of the fragments. Delayed union should be considered to be present if there is no evidence of callus formation at the end of four to six months.

The technic used by the authors is described, and an analysis of 25 consecutive cases in which the method was used are reported. In all cases except 1 bony union developed both clinically and roentgenologically. The average duration for the development of union after drilling was eight weeks, the shortest period of time was three weeks, and the longest was five months. The patients were permitted to be up and walking in casts a week or ten days after operation.

Farill⁶⁶³ describes the technic for a fibular transplant in destruction of the tibial diaphysis by osteomyelitis. He reports 2 cases in which fibula transplants were used from the normal leg. Multiple transverse perforations were placed in the grafts to facilitate nutrition and to hold it in contact with the tibial fragments. The author feels that his technic conserves the line of the fibula of the affected leg and does not endanger the chief supporting bone of the normal leg. The graft is taken from the upper two thirds of the normal fibula.

Nunziata⁶⁶⁴ presents the technic of subastragalar arthrodesis in old fractures of the os calcis. He reviews the various technics for treating fractures of the os calcis and states that if union is not satisfactory arthrodesis is indicated. After the arthrodesis and the postoperative convalescence of one week, a walking cast is applied and the patient is allowed to be up and about. The cast is removed after four months.

XX Conditions Involving the Lower Part of the Back

PREPARED BY R. BEVERLY RANEY, M.D., DURHAM, N. C.

THE year 1944 has seen no spectacular advances toward solution of the many problems of pain in the lower part of the back and sciatic pain. The considerable volume of literature on this subject demonstrates widespread interest, a gradual evolution of certain trends

663 Farill, J. Fibular Graft in Treatment of Destruction of Tibial Diaphysis. Technique of Operation, *Gac. méd. de México* **74**: 392-399 (Aug. 31) 1944.

664 Nunziata, A. Old Fractures of Calcaneum, Subastragalar Arthrodesis, *Prensa med. argent.* **31**: 1881-1883 (Sept. 20) 1944.

of orthopedic thought becomes apparent. There is a healthy tendency to emphasize the basic lesion rather than the symptom of sciatica. Most writing and most controversy still center about the syndrome of the ruptured intervertebral disk and its treatment. Studies of the end results of operations on disks are beginning to appear and should be most helpful, these first statistical reports are not too encouraging. The role of bony changes, such as facet irregularities and isthmus defects, is receiving increased recognition.

Because of the volume of this literature, only the more outstanding articles are reviewed here. For the sake of completeness, however, others are mentioned in proper context and listed in the references.

Pain in the Lower Part of the Back—Many reviews and summaries⁶⁶⁵ of the problem of pain in the lower part of the back appeared in the literature during 1944. In most of these sciatica is discussed as a secondary feature. While adding little to recorded knowledge of the subject, these articles serve a practical purpose in presenting various aspects of the problem in proper perspective and in disseminating current orthopedic opinion to all groups of physicians. Outstanding among general summaries during the year are the papers of Ghormley, Billington and Knight. Yaskin and Finkelstein review in comprehensive fashion the various types of cases characterized by pain in the lower part of the back and sciatic pain. Carey presents a readable summary of essential anatomic and physiologic considerations relating to the normal spine and considered prerequisite to an understanding of

665 Axford, M. Industrial Back with Some Observations on Compensation Aspect, New Zealand M J, April 1943, supp, pp 24-28. Fuldner, R. V. Diagnosis of Minor Back Disabilities, Mil Surgeon **95** 228-232 (Sept.) 1944. Carey, E. J. Anatomical and Physiologic Considerations Prerequisite to Diagnosis of Back Trauma, Radiology **41** 554-559 (Dec.) 1943. Billington, R. W. Causes of Low Back Pain and Sciatica, J Tennessee M A **37** 113-116 (April) 1944. Burt, H. Low Back Pain Its Prevention and Treatment, Brit J Phys Med **7** 11-17 (Jan-Feb.) 1944. Ghormley, R. K. Backache Examination and Differential Diagnosis, J A M A **125** 412-416 (June 10) 1944. Knight, R. A. Disability Due to Low Back Pain, Memphis M J **19** 84-87 (June) 1944. Krida, A. Symposium on Orthopedic Surgery Backache and Sciatica, Clinics **2** 1055-1066 (Dec.) 1943. Magnuson, P. B. Diagnosis of Low Back Pain, Proc Interst Postgrad M A North America (1943), 1944, pp 164-167. McFetridge, S. A. Brief Summary of Back Pain and Interpretation of Orthopaedic Specialists' Reports, Bull Vancouver M A **20** 81-83 (Dec.) 1943. Morris, S. Low Back Pain—Anatomy and Physiology, New Zealand M J, April 1943, supp, pp 28-31. Stucky, E. K. Diagnosis and Treatment of Low Back Pain, Arch Phys Therapy **25** 34-40 (Jan.) 1944. Haggart, G. E. Clinical Observations on Low Back and Sciatic Pain, with Particular Reference to Lumbosacral Joint and to Intervertebral Disk Syndrome, S Clin North America **24** 723-730 (June) 1944. Yaskin, J. C., and Finkelstein, A. Low Back and Leg Pains Some Clinical Considerations, Clinics **3** 261-308 (Aug.) 1944.

the diagnosis of injury of the back Fuldner reviews for medical officers the essential points in the diagnosis of minor disabilities of the back Axford discusses the compensation aspects of injuries of the back in industry

Neurologic aspects of pain in the lower part of the back are discussed by Turner⁶⁶⁶ He points out that pain in the back may be attributed to involvement of either the peripheral nerves or the dorsal roots He considers that neuritis or neuropathy of the nerves of the trunk is rare and that involvement of the spinal roots is the usual mechanism of pain in the back The cause of this involvement may be an infectious process in the meningeal envelopes or in the roots themselves or a mechanical process which stretches or compresses the roots In such radiculitis, motor as well as sensory roots may be involved Turner discusses the pathogenesis and manifestations of radiculitis in a number of common disease entities characterized by pain in the lower part of the back

In a provocative article, Dandy⁶⁶⁷ states his belief that recurring attacks of backache in the low lumbar region, without sciatica, have precisely the same underlying cause as backache plus sciatica, i e, defective intervertebral disks He reports 20 cases in which there were large protruding disks compressing the nerves despite the fact that sciatica had never been present He makes his diagnosis from history, neurologic examination (frequently negative) and roentgen examination of the vertebrae, stating the belief that pathognomonic evidence of defective disks is present in more than half of the cases At operation he locates the defective disk by testing the mobility of the vertebrae Dandy expressed the opinion that defective disks are multiple in 80 per cent of the cases, that spinal injections of any type should be condemned, that complete removal of the disk produces spinal fusion and that spinal arthrodesis of the usual orthopedic type is never necessary He states that persistence or return of backache or sciatica is explained by failure to identify the defective disk, incomplete removal of the disk or the presence of a tumor [ED NOTE (R B R) —Several of these conclusions are contrary to orthopedic experience and for acceptance would require much more confirmatory data than is now available]

The important role of abnormalities of the articular facets in the causation of pain in the lower part of the back has received detailed

666 Turner, C C Neurologic Origin of Back Pain, *Memphis M J* **19** 82-84 (June) 1944

667 Dandy, W E. Treatment of Recurring Attacks of Low Backache Without Sciatica, *J A M A* **126** 1175-1178 (Aug 26) 1944

attention in only two articles Wright⁶⁶⁸ discusses the part played by the facets in the mechanics of locomotion Scott,⁶⁶⁹ reviewing the records of a large naval air center for the first fifteen months of the war, emphasizes the importance of subluxations of the apophysial joints and of the less common fractures of the articular facets He considers oblique roentgenograms to be of great value and describes his technic for making them Roentgenologic diagnosis of subluxations of the apophysial joints is based on the following findings narrowing of the intervertebral disk space, excessive overriding of the articular surfaces of opposing facets and erosion and sclerosis from impingement of the superior articular facet of the lower vertebra on the pedicle of the vertebra above and of the opposing facet on the lamina of the vertebra below For patients with apophysial subluxations and sciatic pain, he advises spinal myelography to determine the presence of an intraspinal protrusion of the disk If this is found to be present, both lesions should be treated surgically

Clinical interest in the ill defined syndrome of fibrositis appears to be declining Fat herniations in cases of pain in the lower part of the back are described by Copeman and Ackerman⁶⁷⁰

A timely presentation of cases of primary lesions of the gastrointestinal tract with pain referred to the back is made by Rivers and Roodenburg⁶⁷¹ They discuss the mechanism of referred pain and describe its typical distribution in each of the common diseases of the gastrointestinal and accessory gastrointestinal tracts Intensification of the pain in the back is thought to indicate a progression of the gastrointestinal lesion Reports of several illustrative cases are presented Rivers and Roodenburg do not include references to possible orthopedic and neurologic findings such as deformity, spasm, tenderness and sensory changes The association of pain in the lower part of the back with endocrine disorders is discussed by Hutton⁶⁷²

There is continued interest in elucidating the physiology and pathologic changes of the lumbosacral junction by means of improved

668 Wright, J Mechanics in Relation to Derangement of Facet Joints of Spine, *Arch Phys Therapy* **25** 201-206 (April) 1944

669 Scott, W G Low Back Pain Subluxations of Apophyseal Joints and Fractures of Articular Facets, *U S Nav M Bull* **43** 234-240 (Aug) 1944

670 Copeman, W S C, and Ackerman, W L "Fibrositis" of Back, *Quart J Med* **13** 37-51 (April-July) 1944

671 Rivers, A B, and Roodenburg, A I Back Pain in Disease of Gastrointestinal and Accessory Gastrointestinal Tract, *J A M A* **125** 421-426 (June 10) 1944

672 Hutton, J H Endocrine Disorders and Low Back Pain *Indust Med* **13** 241-243 (March) 1944

roentgenographic technic and interpretation Brailsford⁶⁷³ and Cornwell⁶⁷⁴ have written on this subject Gianturco⁶⁷⁵ has carried out, by means of roentgenograms, a detailed analysis of the mechanics of flexion and extension of the lower lumbar vertebrae in normal persons and in persons suffering from pain in the lower part of the back Breck, Hillsman and Basom⁶⁷⁶ studied lumbosacral roentgenograms of 450 consecutive male applicants for work in a heavy industry The detailed roentgenographic findings were tabulated No instance of tuberculosis, osteomyelitis or postoperative fusion was encountered In 31 per cent there were significant pathologic changes, however, and in 15 per cent these were considered severe enough to necessitate a refusal of employment The authors conclude that roentgenographic examination of the lumbosacral portion of the spine is of great value as a preliminary to employment in heavy labor The statistics are of particular interest in view of the fact that all the subjects denied having or having had pain in the lower part of the back

Individual methods of treating certain types of pain in the lower part of the back are described in several brief articles Argo⁶⁷⁷ was successful in relieving pain ascribed to ligamentous sprain by injecting procaine hydrochloride locally Turner⁶⁷⁸ discusses the treatment of backache by manipulation, and Rankine⁶⁷⁹ describes therapeutic exercise Isaev⁶⁸⁰ has written on the treatment of pain in the lower part of the back and sciatica with electrical currents of ultra high frequency

Sciatica—In many articles reference is made to pain in the lower part of the back, but chief emphasis is placed on the problem of sciatic pain

673 Brailsford, J F Value of Radiography in Lumbosacral Lesions, M Press **212** 315-319 (Nov 15) 1944

674 Cornwell, W S Lumbosacral Junction, Radiog & Clin Photog (no 1) **20** 2-11, 1944

675 Gianturco, C Analysis of Motion of Lower Lumbar Vertebrae in Normal Individuals and in Patients with Low Back Pain, Am J Roentgenol **52** 261-268 (Sept) 1944

676 Breck, L W, Hillsman, J W, and Basom, W C Lumbosacral Roentgenograms of Four Hundred and Fifty Consecutive Applicants for Heavy Work, Ann Surg **120** 88-93 (July) 1944

677 Argo, W L Novocain Injection for Low Back Strain, Hawaii M J **3** 133-134 (Jan-Feb) 1944

678 Turner, J M Value of Manipulative Surgery in Treatment of Low Back Pain, M Press **212** 202-204 (Sept. 27) 1944

679 Rankine, T G Remedial Exercise for Backache, J Roy Army M Corps **81** 250-251 (Nov) 1943

680 Isaev, V V Ultra-High Frequency Currents in Therapy of Lumboschialgic Syndrome, Nevropat i psikiat (no 4) **11** 91, 1942

In a brief and interesting presentation Jackson⁶⁸¹ analyzed 100 cases of chronic sciatic pain—mostly from British military services—from the standpoints of etiology and of differential diagnosis. In 21 cases the exact cause remained doubtful despite extensive study. In 20 cases sciatica was ascribed to fibrositis, in 18 to ruptured intervertebral disks and in 10 to hysteria. Jackson feels that the influence of neurosis in cases of sciatica has been understressed. Hysteria alone is responsible in some cases and is a secondary and complicating factor in many others. From a detailed tabulation of the symptoms and signs in the entire group of 100 cases, Jackson draws a primary conclusion that there is complete absence of a single clearcut diagnostic syndrome, the majority of the symptoms and signs may occur in any etiologic group. Jackson considers Lasague's test of no value in diagnosis, though useful in evaluating the severity and progress of sciatica. He concludes that ruptured intervertebral disks, fibrositis and neurosis are the three factors of greatest importance in the causation of chronic sciatica in young persons, they correspond with the three types of sciatic pain, viz, neural, referred and functional, into one of which groups each case of sciatic pain should be placed as a preliminary diagnostic step.

Le Vay⁶⁸² presents a study of 40 cases of sciatica in military personnel, with particular emphasis on details of the history and physical examination. He concludes that most cases of sciatica are due to lesions of the intervertebral disks. No evidence suggested that any of the patients were suffering from sciatic neuritis, and the author states that it is difficult to see why this diagnosis should still be made for a group of clinical features shown to be due so often to a proved lesion.

In a contrasting article, Magnuson⁶⁸³ discusses the etiology and pathogenesis of pain in the lower part of the back accompanied by sciatic pain. He points out the frequency of pathologic changes in the lumbosacral joints and discusses their importance as a cause of pressure on the nerve roots and sciatica. Anatomic details are shown in photographs of dissected spines. Reasoning on these data, Magnuson states the belief that "promiscuous operation for and removal of intervertebral disks without definite evidence of root pressure is not justifiable until every other method of treatment has been reasonably tried." He advocates permanent immobilization of the spine at the time of operation for a ruptured nucleus pulposus.

681 Jackson, W. P. U. Differential Diagnosis of Chronic Sciatic Pain. Note, with Short Analysis of One Hundred Recent Cases. *Brit. M. J.* 2: 776-778 (Dec. 18) 1943.

682 Le Vay, A. D. Sciatica. Study of Forty Cases, *Lancet* 1: 116-118 (Jan. 22) 1944.

683 Magnuson, P. B. Differential Diagnosis of Causes of Pain in Lower Back Accompanied by Sciatic Pain, *Tr. South. S. A.* (1943) 55: 345-358, 1944.

Articles on sciatica written in 1944 include also those of Forestier⁶⁸⁴ in French and of Muller⁶⁸⁵ and of Vaubel,⁶⁸⁶ in German. The role of tumors of the caudal medulla and cauda equina in causing sciatica, as well as their surgical therapy are pointed out in two articles from South America—those of Diez⁶⁸⁷ and Estevez⁶⁸⁸.

The year has produced several laboratory studies of the causes of sciatica. Larmon⁶⁸⁹ dissected ten spines obtained at necropsy, observing the relative size of nerve roots and foramens, the effect on the roots of variations in contiguous ligamentous and osseous structures and the effects of swelling of the joint capsules produced by the injection of oil. Such injection produced sufficient swelling of the capsular ligamentum flavum to compress the spinal nerves in the foramens. Other factors found to produce compression of the spinal nerves were posterior lipping of the vertebral bodies, anomalies of the first sacral body, narrowing of the intervertebral foramen due to collapse of the disk and variations in the ligamentous structures adjacent to the fifth lumbar foramen. [ED NOTE (R B R) —This is useful substantiation of some of the postulated causes of sciatic pain, it serves to emphasize the fact that pressure on a nerve root may often be the result of factors other than intraspinal protrusion of an intervertebral disk.] Elliott⁶⁹⁰ has carried out electromyographic studies in cases of sciatica. Most of the tender spots in muscles were found to show increased irritability, representing muscle spasm, which Elliott believes causes pain and tenderness and constitutes the essential change in fibrositis or myositis. Brailsford⁶⁹¹ investigated sciatica and lumbago from the radiologic aspect.

Kelman⁶⁹² reports his technic and results in the use of epidural injection for sciatic pain from various causes. One hundred and

684 Forestier, J. Sciatica as Vertebral Disease, *Lyon méd* **167** 387-391 (May 17) 1942.

685 Müller, I. Sciatica as Sequel of Trauma, *Ztschr f ärztl Fortbild* **39** 76-79 (Feb 15) 1942.

686 Vaubel, E. Localization of Pain in Sciatic Nerve, *Deutsche med. Wchnschr* **69** 49 (Jan. 22) 1943.

687 Diez, J. Tumors of Cauda Equina Diagnosed and Treated Surgically When Stubborn Sciatica Is Only Symptom. Cases, *Rev Asoc méd argent.* **57** 925-929 (Nov 15) 1943.

688 Estevez, R. Fibroma of Caudal Medulla with Sciatica. Surgical Therapy of Case, *Rev méd de Chile* **71** 1207-1210 (Dec.) 1943.

689 Larmon, W A. Anatomical Study of Lumbosacral Region in Reaction to Low Back Pain and Sciatica, *Ann Surg* **119** 892-896 (June) 1944.

690 Elliott, F A. Tender Muscles in Sciatica. Electromyographic Studies, *Lancet* **1** 47-49 (Jan 8) 1944.

691 Brailsford, J F. Investigation of Sciatica and Lumbago. Radiologic Aspect, *Brit J Radiol* **17** 308-311 (Oct) 1944.

692 Kelman, H. Epidural Injection Therapy for Sciatic Pain, *Am J Surg* **64** 183-190 (May) 1944.

sixteen patients were treated with a total of four hundred and eighty-six injections. Eight patients were cured of pain, 41 greatly improved, 45 moderately improved, 17 slightly improved and 5 unchanged [ED NOTE (R B R) —While epidural injection is at times a useful treatment for the symptom of sciatic pain, rational curative therapy must obviously be directed at the causative lesion. When the causes of sciatica are better understood, mere symptomatic treatment will be less used and the percentage of cures will be greater. Progress along these lines is being made.]

Hurst,⁶⁹³ in an article subtitled "An Essay in Debunking," reviews a number of methods of treating sciatica, popular at various times since the beginning of the present century. He attributes most, if not all, of their good results to their psychologic value. For the treatment of sciatica he recommends rest in bed in the average case, fixation by means of a plaster spica in the exceptionally severe case, and in all cases psychotherapy in the form of suggestion that the patient is to expect rapid and complete or almost complete recovery [ED NOTE (R B R) —Sciatica is only a symptom, diagnostic and therapeutic effort should be directed primarily at its cause.]

Intervertebral Disks —The ruptured disk continues to be the subject of many clinical studies and reports. A number of excellent reviews of current knowledge of this syndrome are available in the 1944 literature. The groups of cases are large, the clinical features are stated clearly and the articles make good teaching material. Jelsma⁶⁹⁴ has analyzed 1,000 consecutive cases of pain in the lower part of the back, in 531 of which the cause was a focal neurologic lesion, of these, 484 were diagnosed herniated disk. Adson's⁶⁹⁵ article reviews all important phases of the subject. Poppen⁶⁹⁶ summarizes the clinical findings in 200 cases closely observed at the Lahey clinic. A number of articles⁶⁹⁷ stress recognized

693 Hurst, A. Treatment of Sciatica. Essay in Debunking, Brit. M. J. 2 773-775 (Dec. 18) 1943

694 Jelsma, F. Clinical Analysis of 1,000 Consecutive Cases of Low Back Pain, with Particular Reference to Sciatic Pain Caused by Extrusion of Intervertebral Disk, South M. J. 37 372-378 (July) 1944

695 Adson, A. W. Diagnosis and Treatment of Protruded or Ruptured Intervertebral Disks as Cause for Low Back Pain and Sciatica, Proc. Interst. Postgrad. M. A. North America (1942), 1943, pp. 196-201

696 Poppen, J. L. Management of Ruptured Intervertebral Disks. Proc. Interst. Postgrad. M. A. North America (1943), 1944, pp. 118-120

697 Gardner, W. J. Protrusion of Intervertebral Disk. Common Cause of Sciatica, Cleveland Clin. Quart. 11 66-74 (July) 1944. Wilson, A. A. Clinical Aspects of Protruded Intervertebral Disk, West Virginia M. J. 40 107-111 (April) 1944. Taffel, M. Herniation of Intervertebral Disk and Low Back Pain. New

features of this entity and add little that is new. The structure, functions and lesions of intervertebral disks are discussed by Roberts⁶⁹⁸ and by Putschar,⁶⁹⁹

Keegan⁷⁰⁰ presents an outstanding analysis of the neurologic diagnosis of herniation of the lumbar intervertebral disks. He has constructed a composite dermatome chart of the lower extremity, determined by hypalgesia from losses of a single nerve root, which should be most useful. His discussion of the neurologic mechanisms involved in the ruptured disk syndrome is enlightening.

Echols⁷⁰¹ discusses the neurologic lesions which cause pain in the lower part of the back and sciatic pain, his review of this group of disorders serves as a useful background on which to project in detail the neurologic picture of the ruptured intervertebral disk. The neurologic diagnosis and differential diagnosis are clearly drawn.

Dandy⁷⁰² has stimulated much discussion by presenting several new conceptions of various aspects of the ruptured disk syndrome. He considers that anatomic variations of the lumbar articular facets form an important factor in the causation of defective lumbar intervertebral disks. He expresses the opinion that the sequence of events in pain in the lower part of the back and sciatica is as follows: 1. A sudden severe lift or twist tears the capsule at the lateral articulation and loosens the joint. 2. These loose joints automatically throw an additional strain on the intervertebral cartilages. 3. The result of this sustained trauma is an injured disk, which protrudes and impinges on the emerging spinal nerve. He expresses the opinion that defective lumbar intervertebral disks are nearly always multiple or potentially multiple and that failure to appreciate this is a principal reason for disappointing results from surgical treatment. He states the belief

Zealand M. J., April 1943, supp., pp. 22-23. Gross, S. W. Intervertebral Disk Protrusions in Military Practice, *Tr. Am. Neurol. A.* **69**: 119-123, 1943. Oppenheimer, A. Pathology, Clinical Manifestations and Treatment of Intervertebral Disk Lesions, *New England J. Med.* **230**: 95-105 (Jan. 27) 1944. Peyton, W. T., and Levin, J. D. Posterior Herniation of Intervertebral Disks. Analysis of Sixty-Five Cases, *Minnesota Med.* **27**: 263-273 (April) 1944.

698. Roberts, F. Nature and Functions of Intervertebral Disks, *Brit. J. Radiol.* **17**: 54-59 (Feb.) 1944.

699. Putschar, W. G. J. Pathology of Intervertebral Disks, *West Virginia M. J.* **40**: 101-107 (April) 1944.

700. Keegan, J. J. Neurosurgical Interpretation of Dermatome Hypalgesia with Herniation of Lumbar Intervertebral Disk, *J. Bone & Joint Surg.* **26**: 238-248 (April) 1944. Diagnosis of Herniation of Lumbar Intervertebral Disks by Neurologic Signs, *J. A. M. A.* **126**: 868-873 (Dec. 2) 1944.

701. Echols, D. H. Neurologic Aspects of Low Back Pain and Sciatica, *J. A. M. A.* **125**: 416-420 (June 10) 1944.

702. Dandy, W. E. Newer Aspects of Ruptured Intervertebral Disks, *Ann. Surg.* **119**: 481-484 (April) 1944.

that a reduced interspace in the roentgenogram indicates that a fusion or partial fusion has occurred. He proposes a thorough curettage of the interior of the disk, extraction of its contents and removal of the protruding portion, stating the belief that the result will be fusion of the entire vertebral surfaces. Dandy has treated 15 patients with backache and sciatica, 6 with congenitally defective lumbar vertebrae and 10 with spondylolisthesis by removal of the intervertebral disk to produce vertebral fusion. The results in cases of backache without sciatica were precisely the same as in those with sciatica. Dandy pays a tribute to Goldthwait, who in 1911, eighteen years before protrusion of a disk was first recognized at operation, suggested the possibility of rupture of a disk as a cause of nerve root pain. [ED NOTE (R. B. R.) —A larger series of observations would be required to establish these beliefs, many of which are at variance with well founded orthopedic opinion.]

French and Payne⁷⁰³ report on a group of 8 patients who had large protrusions of intervertebral disks compressing the cauda equina. They point out the difficulty of differentiating this type of disk lesion from cauda equina tumor. These patients had pain in the lower part of the back and in both lower extremities, with numbness in the saddle area, both lower extremities or both of these locations, they also had weakness and sphincteric disturbances. A long history of pain in the back followed by an acute episode of rapid progression of the symptoms was typical. The physical findings included weakness or atrophy in the gluteal region or the lower extremities or both, with sensory changes, multiple reflex changes and abnormalities of the sphincters. The spinal fluid protein was increased. Roentgenograms showed narrowing of the lumbosacral interspace, and myelography demonstrated a complete or nearly complete subarachnoid block. The treatment included surgical removal of large nucleus protrusions which were severely compressing the dural sac, in 3 of the cases spinal fusion also was carried out.

Echols⁷⁰⁴ reports the case of a 39 year old man who had two ruptured lumbar intervertebral disks, one of which followed the other by two and a half years and appeared to be of nontraumatic origin.

O'Connell⁷⁰⁵ discusses maternal obstetric paralysis and reports 4 cases of this paresis of the lower extremities in which ruptured lumbar disks were found. He states the belief that relaxation of the pelvic

703 French, I. D., and Payne, J. T. Cauda Equina Compression Syndrome with Herniated Nucleus Pulposus. Eight Cases. *Ann Surg* **120** 73-87 (July) 1944.

704 Echols, D. H. Rupture of Fourth and Fifth Lumbar Disks with Bilateral Sciatic Pain. *Circ. Texas State J. Med* **39** 477-479 (Jan.) 1944.

705 O'Connell, I. E. A. Maternal Obstetric Paralysis. *Surg., Gynec. & Obst* **79** 374-382 (Oct.) 1944.

joints due to an endocrine factor may facilitate rupture of a disk, particularly in the presence of the abnormal mechanical stresses of pregnancy and labor. For prophylaxis he advises against any type of heavy work during pregnancy [ED NOTE (R B R) —It is common orthopedic experience to encounter young mothers whose pain in the back began during pregnancy or immediately afterward. So far as this editor knows, statistics on the incidence of lesions of the intervertebral disks in this group of patients are not available. As additional prophylactic treatment for pregnant women in whom backache develops, the use of a maternity corset may be advisable.]

In the diagnosis of lesions of the intervertebral disks, contrast myelography occupies, in the opinion of most observers, an important place. Copleman⁷⁰⁶ advocates its use in every case of suspected rupture of an intervertebral disk, for the purpose of demonstrating the level of the protrusion, whether it is single or multiple and whether the defect is due to a lesion of a disk or to a tumor. He uses Pantopaque, aspirating it at the end of the fluoroscopic examination. Copleman favors Pantopaque because of its low viscosity, failure to produce reaction, tendency to remain homogeneous and partial transparency. Lang and Fishback⁷⁰⁷ discuss various types of contrast myelography and their localization value. The observations on examination with Pantopaque were verified at operation. The findings on examination of 18 patients with the use of iodized poppyseed oil were also proved correct at operation, of nineteen air myelographies, only one was interpreted inaccurately. The authors conclude that localization by contrast myelography may be 95 per cent correct [ED NOTE (H H K) —This excellent percentage is not always obtained. In a series of one hundred and forty-four myelographies with iodized poppyseed oil known to me, the diagnosis was proved to be accurate in 82 per cent.] Bradford,⁷⁰⁸ discussing the management of ruptured intervertebral disks among naval personnel, advises contrast myelography, advocates Pantopaque and describes the technic in detail. Eaglesham⁷⁰⁹ gives the technical details of myelography with iodized poppyseed oil and with Pantopaque (ethylodophenylundecylate) and discusses the roentgenographic interpretation.

706 Copleman, B. Roentgenographic Diagnosis of Small Central Protruded Disk, Including Discussion of Use of Pantopaque as Myelographic Medium, *Am J Roentgenol* **52** 245-252 (Sept.) 1944

707 Lang, E. F., and Fishback, H. R., Jr. Myelography in Diagnosis of Ruptured Intervertebral Disks, *Harper Hosp Bull* **2** 34-38 (April) 1944

708 Bradford, F. K. Intervertebral Disk Problem in the Navy, *U S Nav M Bull* **42** 763-775 (April) 1944

709 Eaglesham, D. C. Opaque Myelography of Lumbar Disk Herniations, *Brit. J Radiol* **17** 343-348 (Nov.) 1944

Sufficient experience with the treatment of patients with ruptured intervertebral disks has now made possible an evaluation of the therapeutic results. A number of articles devoted primarily to analyses of end results are available in the literature of 1944. Grant⁷¹⁰ reports on 150 patients, with a follow-up period of from six months to five years. Seventy-eight patients were cured, 56 improved and 16 unimproved by removal of the disk, spinal fusion was not done. As a result of his experience, Grant states "No patient suspected of having a ruptured disk is considered for operation unless he has had two or more attacks of pain and unless the pain is severe at the time he presents himself in clinic." Shinnars and Hamby⁷¹¹ found that of 87 patients whose disk protrusions had been removed at least six months before 43 considered themselves cured, 42 considered themselves improved and 2 thought themselves in some way worse than before operation. Fusion was done in only a small percentage of these cases.

Smith, Deery and Hagman⁷¹² present an analysis of 100 patients who had removal of ruptured intervertebral disks. In 70 patients in whom spinal fusion also was done, observation at least one year after operation showed that 24 had excellent results, 33 good and 13 poor. Of 12 patients in whom only removal of the disk was carried out, 5 had excellent results, 5 good and 2 poor. The authors are convinced that in many instances of ruptured disk there is a deranged or unstable lumbosacral joint and that after removal of the disks such backs should be fused. Henry⁷¹³ stresses the value and describes the procedures of conservative treatment, advising removal of the disk and spinal fusion only if pain persists despite thorough nonoperative treatment.

Botterell, Keith and Stewart⁷¹⁴ analyzed a group of 51 Canadian soldiers who were explored with the preoperative diagnosis of herniation of a lumbar intervertebral disk. Of these, 29 returned to full duty and 14 to sedentary duty, and 8 were unfit for military service. They

710 Grant, F. C. Operative Results in Intervertebral Disks. *J. Neurosurg.* **1** 332-337 (Sept.) 1944

711 Shinnars, B. M., and Hamby, W. B. Results of Surgical Removal of Protruded Lumbar Intervertebral Disks. *J. Neurosurg.* **1** 117-122 (March) 1944

712 Smith, A. De F., Deery, E. M. and Hagman, G. L. Herniation of Nucleus Pulposus. One Hundred Cases Treated by Operation. *J. Bone & Joint Surg.* **26** 821-828 (Oct.) 1944

713 Henry, M. O. Conservative Treatment of Disk Syndrome. *Minnesota Med.* **27** 809-811 (Oct.) 1944

714 Botterell, F. H., Keith, W. S., and Stewart, O. W. Results of Surgical Treatment of Sciatica Due to Herniation of Intervertebral Disk in Canadian Soldiers Overseas. *Canad. M. A. J.* **51** 210-214 (Sept.) 1944

stress the necessity of careful selection of cases and state that the patient most likely to be returned to full duties possesses these characteristics

His age is less than 35 and preferably under 30. He is suffering acutely from sciatica and has had some degree of disability, continuous or recurrent, for three to six months in spite of a variety of treatments. He has no physical defects other than those attributable to sciatica. His army career has been a reasonably happy and successful one. He is not anxious to be discharged from the army on account of domestic difficulties and he is considered emotionally stable apart from the inevitable effects of the pain and restricted activity.

In the French literature, late results of laminectomy have been reported by Petit-Dutaillis, Ribadeau-Dumas and Messimy⁷¹⁵ and beneficial effects of laminectomy have been discussed by Carrot and David⁷¹⁶.

The surgical technic of removing disk protrusions is discussed in two articles⁷¹⁷ from the military services.

Defects of the Neural Arch and Spondylolisthesis—Few articles on this subject appeared during the year. Galluccio,⁷¹⁸ in the routine roentgenographic examination of 142 persons, found 15 with prespondylolisthesis or spondylolisthesis. The subjects consisted of soldiers exposed to many types of hazards and of an average age of 28 years. Galluccio expresses the belief that spondylolisthesis and prespondylolisthesis are much more prevalent than is ordinarily recognized and that diligent search for the isthmus defect will reveal it in many unsuspected cases. He describes in detail the roentgenographic findings in spondylolisthesis and prespondylolisthesis in roentgenograms made in the anteroposterior, lateral, oblique and lumbosacral projections. He considers the oblique view extremely important for diagnosis and calls attention to a "bow tie" appearance presented by the superior articular process, the pars interarticularis and the inferior articular process of each lumbar vertebra.

715 Petit-Dutaillis, D., Ribadeau-Dumas, C., and Messimy, R. Late Results of Laminectomy for Sciatica Due to Herniated Disks, *Rev. neurol.* **74** 225-226 (July-Aug.) 1942.

716 Carrot, E., and David, M. Surgical Therapy of Stubborn Sciatica in Young Adults. Relative Rarity of Hernia of Intervertebral Disks, Beneficial Effects of Laminectomy, *Rev. neurol.* **74** 281-282 (Sept.-Oct.) 1942.

717 Shelden, C. H. Protruded Intervertebral Disk. Advantage of Upright Position in Surgical Removal, *U. S. Nav. M. Bull.* **42** 1107-1110 (May) 1944.
Robertson, R. C. L., and Peacher, W. G. Herniated Nucleus Pulposus. Improvement in Operative Technic, *Bull. U. S. Army M. Dept.*, August 1944, no. 79, pp. 76-77.

718 Galluccio, A. C. Spondylolisthesis, General Consideration with Emphasis on Radiologic Aspects, *Radiology* **42** 143-158 (Feb.) 1944.

Caldwell⁷¹⁹ has analyzed 59 consecutive cases of spondylolisthesis. He thinks that pain in the lower part of the back may be caused by the neural arch defect even when slipping cannot be demonstrated and that in other cases spondylolisthesis may be asymptomatic even when the displacement is severe. Caldwell found that among patients with complaints of pain in the lower part of the back severe enough to require medical attention 1 out of 10 was likely to have prespondylolisthesis or spondylolisthesis, of patients referred to orthopedists after other conditions had been ruled out, 1 out of 5 had neural arch defects. Caldwell emphasizes the importance of roentgenograms and requires a minimum of three views, consisting of the direct anteroposterior view, true lateral view focused on the fifth lumbar vertebra and 35 degree anteroposterior view with the rays directed toward the head and centered between the sacrum and the fifth lumbar vertebra. He states that these roentgenograms will clearly define any neural arch defect with separation and most of those without separation. He states the belief that unilateral neural arch defects may require confirmation by 45 degree oblique lateral roentgenograms but that these are not essential for routine examination. Of the 59 patients 16 had prespondylolisthesis, and in 9 of these the defect was unilateral. Caldwell reviews the evidence on progressive slipping in spondylolisthesis and concludes that it seldom occurs in adult life. The cause of symptoms is probably the progressive narrowing of the intervertebral disk, with degenerative changes in the disk and proliferative changes in the bone about the intervertebral foramina. Symptoms produced by lumbosacral arthritis, especially in middle-aged persons not engaged in heavy labor, can usually be adequately relieved by braces, corsets, physical therapy and postural exercises. Younger patients with disabling symptoms may require operative treatment, it probably would be sufficient to fuse the lumbosacral articulation alone instead of attempting to bridge from the third lumbar vertebra to the sacrum with a bone graft. When sciatic pain is associated with spondylolisthesis, the nerve root should be explored and decompressed, either by liberation from bony constriction or by removal of a protruded intervertebral disk. Caldwell suggests that from a theoretic viewpoint the symptoms in certain cases might best be relieved by removal of the attached neural arch and the inferior articular processes. Liberation of the nerve roots without fusion of the articulations or bridging of the defect with a bone graft should be supplemented by postural exercises and support of the lower part of the back.

719 Caldwell G A Spondylolisthesis, Analysis of Fifty-Nine Consecutive Cases, *Tr South S A* (1943) 55 196-208 1944

Congenital Lumbosacral Anomalies—Meredith⁷²⁰ presents 3 illustrated reports of cases of spina bifida associated with lesions of the nerves producing serious symptoms which were relieved by neurosurgical treatment. Taylor⁷²¹ discusses common anomalies of the lumbar portion of the spine. Andre,⁷²² in Belgian literature, discusses spina bifida with neurotrophic changes in the lower extremities.

Technic of Spinal Fusion—Individual variations in the surgical technic of spinal arthrodesis continue to be reported. Briggs and Milligan⁷²³ advocate the use of many minute chips of bone packed closely together. In lumbosacral fusions King⁷²⁴ has effected internal fixation by transfixing the articular facets with vitallium screws.

Ramser⁷²⁵ described the use of a three-flanged nail in a transabdominal operation for nontraumatic spondylolisthesis.

Thomas⁷²⁶ outlines the postoperative management of cases of fusion with and without hemilaminectomy.

Pain in the Lower Part of the Back—Willis⁷²⁷ (reviewed by John R. Cobb, M.D.), in a symposium on backache, reviews the structure and development of the spine and discusses the anatomy and variations and anomalies of the spine. He reports anatomic studies of seven hundred and forty-eight skeletons, some of which were previously reported in his other papers, and discusses the upright posture and its effect on the lower part of the back and symptoms low in the back.

He points out that since man's back is liable to defects and anomalies of growth and development and because an evolutionary shortening of

720 Meredith, J. M. Unusual Congenital Anomalies of Lumbosacral Spine (Spina Bifida) with Report of Three Cases, *J Nerv & Ment Dis* **99** 115-133 (Feb.) 1944.

721 Taylor, W. B. Congenital Anomalies of Lumbar Spine, *J Canad M Serv* **1** 529-534 (Sept.) 1944.

722 Andre, M. J. Sporadic Plantar Mal Perforant and Pes Cavus. Question of Lumbosacral Syringomyelia or Myelodysplasia, *J belge de neurol et de psychiat* **41-42** 340-354, 1941-1942.

723 Briggs, H., and Milligan, P. R. Chip Fusion of Low Back Following Exploration of Spinal Canal, *J Bone & Joint Surg* **26** 125-130 (Jan.) 1944.

724 King, D. Internal Fixation for Lumbosacral Fusion, *Am J Surg* **66** 357-361 (Dec.) 1944.

725 Ramser, R. Transabdominal Surgery for Non-Traumatic Spondylolisthesis, with Special 3-Flanged Nail and Replacement of Intervertebral Disk by Substantia Spongiosa Following Preliminary Extension Reduction, *Helvet med acta* **10** 365-375 (June) 1943.

726 Thomas, G. L. Post-Operative Management of Fusion With and Without Hemilaminectomy, *S Clin North America* **24** 599-602 (June) 1944.

727 Willis, T. A. Structure and Development of the Spine, *J A M A* **125** 407-412 (June 10) 1944.

the vertebral column at the lumbosacral junction is still going on and this same part has been particularly involved in the transition from the pronograde to the upright posture, it is particularly apt to develop symptoms of strain and irritation of nerve roots of mechanical origin

The importance of adequate roentgenographic studies and interpretations is stressed, and reproductions illustrate the various types of congenital variations

In studying several hundred macerated skeletons, he found that beginning at about the thirty-fifth year of age there is a progressive lipping and calcification at the peripheries of the vertebral bodies and of the joints at the attachments of the synovial membrane and ligaments. This is most pronounced in thick-boned, heavy skeletons and least so in the long slender skeletons. It appears first and to the greatest degree in the sacroiliac and lower lumbar areas. In the former it ultimately results in calcification of the anterior sacroiliac ligament, which usually starts at the pelvic brim and extends toward the upper and the lower poles of the joint, often resulting in complete bridging and bony ankylosis of the joint. Because this bridge is thin and has a background of thick dense bone it often is not shown on roentgenograms. Its presence is suggested by a hazy appearance, with indistinctness of outline of the joint. In the lumbar and lumbosacral areas the hypertrophic process involves particularly the vertebral bodies and often progresses to ankylosis of adjacent segments. It also involves the articular process but is more difficult to show here in roentgenograms.

He expresses the belief that since spondylolisthesis has not been found in a fetus or in any of the anthropoids it apparently is due to assumption of the upright posture or to some human custom in the care of infants, and the etiology is still under dispute. As previously reported, he found a higher percentage of defects in the neural arch in the spinal columns which showed an increased number of presacral segments.

Although a reverse spondylolisthesis or backward displacement of the last lumbar vertebrae on the sacrum has been described by several authors after careful analysis of their descriptions and illustrations he is of the opinion that this diagnosis is based on faulty interpretation of the roentgenograms and is really an optical illusion due to the difference in anteroposterior depth of the last lumbar and first sacral vertebral bodies.

Jostes²²⁸ (reviewed by John R. Cobb, M.D.) feels that in recent years the surgical approach in the treatment of painful irritation in the

728 Jostes, F. A. Place of Manipulative Procedures in the Overall Treatment Rationale for Painful Back Condition. *Arch. Phys. Therapy* 25:716-720 (Dec.) 1944

back and sciatic region has done much to mask the rationale of conservative treatment and that since it has been proved that operation is not always indicated for disk involvement and in many cases is futile it may be well to summarize a few facts about the conservative treatment of disabling conditions of the back

He states that it is well known that backache may be the result of any of a large number of causative factors, and he gives a brief outline of the causes of backache, listing them under the main headings of (1) diseases, (2) congenital anomalies, (3) trauma and (4) postural defects

He discusses the various conditions under these main groups and feels that in only a small percentage of cases is surgical intervention really indicated. He discusses over-all methods of treatment and suggests methods of active treatment, comprising rest in bed, heat, massage, manipulations, support, exercise and operation. He reports observations on a large series of cases in private practice and in four dispensaries from 1930 through 1941 and in the military service from 1941 to 1944. About 90 per cent were seen before 1941 and about 10 per cent after that year. Of the total, the condition in about 65 per cent was not acute (not necessarily the first attack) and in 35 per cent chronic (not necessarily because of repeated attacks, since frequently the first attack was of chronic nature). Treatment was carried out by hospitalization methods in about 15 per cent of cases, by semiambulatory methods (home treatment ranging from total to partial rest in bed) in about 50 per cent and by ambulatory methods in about 35 per cent.

He outlines the methods of treatment utilized in this series of cases

I Bed rest (at least for a time), in about 66 per cent.

II Application of heat, infra-red mostly, in about 35 per cent

III Massage—Extensive, in about 5 per cent. Limited in about 65 per cent as part of the manipulative procedure

IV Exercise after subsidence of acute exacerbations, in about 30 per cent (exercise of muscles whose increase in development was essential to maintain posture correction, also exercises to maintain wide range of motion of joints as a guard against further attacks due to overt acts in which a wide range of motion would be suddenly carried out and an acute exacerbation of back pain thus precipitated)

V Use of artificial supports—

A Temporary (one week to three months), in about 15 per cent (types of support wide stocknet bandage, Osgood brace and simple wide canvas belt with or without pads)

B Permanent (more or less), chiefly for women (corsets), in about 8 per cent (an Osgood brace or Goldthwaite brace used alone or in addition to corsets for women, often two heavy, wide mental stays plus one cross bar were used

to obtain more rigidity than ordinary heavy boning of the back of a corset could offer)

C Shoe supports and changes in about 16 per cent (these included raising and lowering of heels, lifts and wedges)

VI Manipulation without anesthesia, in about 65 per cent

VII Prescription of postural changes, in about 40 per cent (postural rest periods on any flat firm surface, postural corrections, standing and sitting and lying down)

VIII Operations, in about 5 per cent (operation for ruptured nucleus pulposus, in 14 per cent, stabilizing operation because of anatomic weakness, in 25 per cent, stabilization operation because of disease, in 11 per cent

Jostes feels that in regard to ruptured nucleus pulposus, after these years of trial the number of cases will be reduced in the future. He feels that the advantage of employing manipulative technic without anesthetic is that the conscious patient is an efficient check on the amount of force necessary and the patient often supplies a ready signal to let the operator know when the reduction as such has been accomplished or relief comes. He expresses the belief that every well trained practitioner of medicine should know that manipulation may afford relief or partial relief if it is indicated and is properly carried out.

ED NOTE (J R C) —It is well to bring out from time to time the significance of conservative treatment as this author has done. A high percentage of patients with painful conditions in the back can be relieved by conservative methods, and too frequently the orthopedic surgeon is inclined to think in terms of operative procedures, without giving the patient an adequate trial of conservative measures. Even though the roentgenograms show some definite defect, it does not necessarily follow that that is the cause of the patient's complaint and it may be only a concomitant occurrence.]

Mock ⁷²⁹ (reviewed by John R. Cobb, M D), in an introduction to a symposium on injuries of the back, makes a plea for better study and treatment for the rehabilitation of patients with pain in the lower part of the back. He expresses the opinion that there is no field in medicine or surgery in which changing styles in diagnosis and treatment have been so numerous as in this condition of pain low in the back, recalling such popular diagnoses as "railway spine" "sacroiliac sprain" and the present "herniated disk." He admits that surgical treatment is necessary for the relief of certain definite conditions such as cord tumors, but stresses the point that to select patients who need these more complicated or radical surgical procedures is the greatest problem con-

fronting surgeons today. He emphasizes the importance of careful study to avoid the overlooking of the psychogenic causes, the postural causes, the muscle imbalance and the numerous constitutional causes that are the predominant factors in the average run of cases of pain in the lower part of the back.

XXI Conditions Involving Shoulder, Neck and Jaw

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Lesions Due to Injury and Disease of Bursae and Tendons About the Shoulder Joint—In regard to motion about the shoulder joint, Fisk⁷³⁰ proposes to show that practically 50 per cent of motion at the shoulder joint occurs as a result of the movements of the scapula and the clavicle and not so much of those of the scapulohumeral joint. Roentgenograms taken in eight key positions demonstrate this fact, and the technic is also described.

Movements of the scapulohumeral joint are limited to 90 degrees of rotation with arm by the side, rotation of 90 degrees with the arm abducted, no movement at all with the arm vertically elevated, abduction of 90 degrees in coronal plane and elevation of 90 degrees in the sagittal plane.

Hamsa⁷³¹ discusses the intricate construction of the shoulder joint and the relationship of capsules and tendons to that joint. The bursa about the joint is discussed, especially the subacromial, and the diagnosis of conditions affecting this bursa and surrounding periarticular structures. Diagnosis and its relationship to applied anatomy of conditions involving the shoulder is the main theme of this paper. Physical therapy is recommended for treatment.

A discussion of injuries occurring in conjunction with the various periods of training of the parachutist was presented by Lord and Coutts⁷³². The four stages are calisthenics with rope climbing, tumbling and jumps from mock towers, daily jumps from 250 foot (76 meters) towers and jumps from planes. Rope climbing produces tears in rectus abdominis muscles with symptoms simulating appendicitis, with

⁷³⁰ Fisk, G. H. Some Observations of Motion at Shoulder Joint, *Canad M A J* **50** 213-216 (March) 1944.

⁷³¹ Hamsa, W. R. Diagnosis and Treatment of Common Shoulder Disabilities. *Omaha Mid-West Clin Soc* **5** 88-90 (Aug) 1944.

⁷³² Lord, C. D., and Coutts, J. W. Typical Parachute Injuries. Study of Those Occurring in 250,000 Jumps at Parachute School, *J A M A* **125** 1182-1187 (Aug 26) 1944.

90 per cent of the injuries in the right rectus. Tumbling produces acromioclavicular separation. The mechanism of this injury is discussed. In the third and fourth group, because of changes in technic of landing, the typical injury has changes from trimalleolar fractures of the ankle to upper fibular fracture or dislocation of head of fibula. The mechanics of such fractures and dislocations are discussed.

Standards of parachute schools and selection of candidates are discussed.

Garceau⁷³³ discusses the frequent "homely" complications occurring in and about the shoulder joint in prolonged immobilization of this joint secondary to injuries of elbow, forearm and hand. Personal instructions to patients so that adequate home physical therapy is carried out will prevent many complications. Periarthritis is a frequent complication. Reports of cases are presented.

Operative repair of ruptures of the supraspinatus tendons is advocated by Jones,⁷³⁴ in an article in which he discusses complete supraspinatus rupture. He points out that the injury is rarely diagnosed in living persons, while postmortem statistics show 15 to 20 per cent in unselected cadavers of persons over 30 years. Subacromial bursitis, bursal calcifications, periarthritis and rupture of the long head of the biceps are frequent complications and sequelae that accompany and mask rupture of supraspinatus tendon. Chronic painful shoulders that do not respond to conservative treatment should be explored by means of a Cubbins transacromioclavicular incision. This allows proper exposure for recognition as well as repair. Frequently accompanying tendons are torn along with the supraspinatus.

A posterior approach to the shoulder joint is discussed by Rowe and Yee⁷³⁵. The patient is placed face down, with a pillow under the chest and with the arms outstretched. The incision begins at the junction of the middle and inner thirds of the spine of the scapula and extends along the spine and posteriorly over the shoulder joint. The deltoid attachment to the spine of the scapula is divided by sharp dissection and split $1\frac{1}{2}$ inches (3.8 cm) from the medial border for 3 inches (7.6 cm) to avoid injury to the nerve and to the muscle. The infraspinatus and the teres minor muscle are exposed and separated and the former freed from the capsule and divided at its tendinous attachment $\frac{1}{2}$ inch (1.2 cm) from the humeral tuberosity. The capsule

733 Garceau, G. J. Shoulder Complications in Injuries of Elbow, Forearm or Hand, *Proc. Interst. Postgrad. M. A. North America* (1942) 1943, pp. 300-302.

734 Jones, L. Complete Rupture of Supraspinatus Tendon. Simplified Operative Repair, *Arch. Surg.* **49**: 390-398 (Dec.) 1944.

735 Rowe, C. R., and Yee, L. B. K. Posterior Approach to Shoulder Joint, *J. Bone & Joint Surg.* **26**: 580-584 (July) 1944.

is then opened. Two cases are presented in which the operation was used for open reduction of posterior dislocation of the shoulder.

Sycamore,⁷³⁶ in five hundred routine examinations of the chest of the freshman class at Dartmouth College, found a definite rhomboid fossa present when a double contour could be seen on the roentgenogram. An incidence of 121 cases, or 24 per cent, was revealed, in 58 per cent there was bilateral fossae, and in 42 per cent there was a unilateral fossa. The fossa can be either shallow or deep and is situated 1 to 3 cm from the sternal end of the clavicle. Its various forms are illustrated.

A more concise terminology for peri arthritis, based on cause, pathologic changes and clinical picture, is suggested by Tarsy.⁷³⁷ Two forms of therapy have been employed for the treatment of this deformity: (1) injection of the specific muscular and tendinous structures involved and (2) block anesthesia and manipulation.

Thirty-four patients were treated, 27 obtained freedom from pain and complete mobility, 3 were partially helped and 4 obtained unsuccessful results.

Lippmann⁷³⁸ makes an important contribution in calling attention to the frequency of bicipital tenosynovitis in cases of peri arthritis. He has studied 32 cases of so-called frozen shoulder. In all instances the subacromial bursa and the underlying musculoaponeurotic cuff were carefully explored and their condition noted and the bicipital tendon was exposed by incision through the deltoid.

In 2 cases only tears of the cuff were encountered, 1 partial and 1 complete. In 2 cases bursal adhesions without tears of the cuff were encountered. In all other cases the appearance of the synovia of the subacromial bursa was smooth and glistening, the sac contained no fluid, and there were no adhesions. Lippmann also found the underlying musculotendinous cuff entirely normal.

On the other hand, all cases in which exploration was done showed inflammatory changes in varying degrees involving the biceps tendon and sheath. There was, furthermore, in these cases a variable degree of impairment of motion of the biceps tendon in its groove caused by peritendinous adhesions. In the early cases, the tissues were reddened, vascular and edematous and the tendon was swollen and discolored. In the more chronic cases, the sheath was thickened, fibrotic and less vascular and the tendon was roughened and scarred.

736 Sycamore, L. K. Common Congenital Anomalies of Bony Thorax, *Am. J. Roentgenol.* **51** 593-599 (May) 1944.

737 Tarsy, J. M. Peri arthritis of Shoulder Joint. Classification, Pathology and Treatment, *New York State J. Med.* **44** 2109-2117 (Oct. 1) 1944.

738 Lippmann, R. K. Bicipital Tenosynovitis, *New York State J. Med.* **44** 2235-2240 (Oct. 15) 1944.

The striking fact was that in the early cases the tendon was still movable but that in the majority of the later cases it had become firmly bound down to the humerus with strong adhesions

Lippmann feels that bicipital tenosynovitis is a pathologic change encountered with great frequency in the so-called frozen shoulder. The question is whether this is the underlying pathologic factor. The ultimate fusion of the tendon to the biceps groove suggests the explanation for the spontaneous cure, which so often occurs. In this connection, it is interesting to recall that Horowitz found in four of fifty anatomic dissections of shoulders fusions of the biceps tendons to the lesser tuberosity with rupture of the intra-articular portion.

In respect to the treatment, it would follow that a forced brisement in the early part of the illness is useless and tearing of the soft adhesions in the presence of pronounced inflammation serves only to cause more pain and more adhesions.

The author states that his experience with roentgen ray therapy in mild analgesic doses in over 30 cases was disappointing.

On the other hand, in the latter part of the disease the forcible manipulation with the patient under anesthesia occasionally produces startling results. Loud snaps are audible during the procedure, probably from the result of rupture of the attenuated and functionless intra-articular tendon.

However, he states the belief that stretching of the arm at regular intervals, with active exercise, is more logical. A surgical method which suggests itself is firm suture of the involved tendon to the adjoining lesser tuberosity. In operations performed during earlier stages of the frozen shoulder, the tendon is still mobile, and prompt relief from pain and improvement in the shoulder result. Motion follows rapidly.

From Lippmann's surgical investigation of more than 30 cases, it seems that involvement of the biceps tendon in most instances of frozen shoulder is a major factor and should be given special consideration when a specific diagnosis is being made and that in most instances the bursa and underlying cuff are not involved.

The susceptibility of the long head of the biceps tendon to both specific and nonspecific infections is discussed by Schrager⁷³⁹ with regard to the anatomic factors, physiologic factors and pathologic factors. Painful or frozen shoulders in the absence of bursitis or pathologic changes of the joints are due to tenosynovitis of the long biceps tendon. Syphilis of tendons and tendon sheaths is discussed with regard to history. Etiology and diagnosis are mentioned, and the pathologic

739 Schrager, V. L. Syphilis of Tendon of Long Head of Biceps Muscle and of Olecranon Bursa, *Arch Surg* 48 423-428 (June) 1944

picture of the presence of nodules in the tendon in syphilis is discussed. They are painless and movable and are a tertiary manifestation. Thick tendons seem to have a predilection in syphilis. Bursitis due to syphilis is also discussed, and the subpatellar and the prepatellar bursae are mentioned as common sites. Syphilis of bursae and tendons should be suspected more often in the diagnosis of tendinitis and bursitis.

Guido⁷⁴⁰ presents a short review of the current methods of treatment for subacromial bursitis with associated calcareous deposits. He advocates operative removal in cases in which the deposit does not disappear spontaneously. The result is immediate, with complete relief, and Guido has not seen any recurrent lesions from the operation.

Pelner⁷⁴¹ discusses acute subdeltoid bursitis and suggests intravenous injection of 5 cc of ferric cacodylate. He states that treatment is so effective that if relief is not obtained immediately then the diagnosis of bursitis is incorrect. Seventy-five patients were treated over a five year period. Duration was no handicap. Two to five treatments were necessary at three day intervals. Complications due to toxicity were negligible.

Young⁷⁴² presents a case of calcified bursitis of the elbow joint successfully treated with roentgen rays and diathermy. The patient made a complete recovery, and the calcareous deposits gradually diminished. This case is presented because of the almost immediate relief of pain under treatment. He refers to Baird's report of 44 cases of calcified bursitis, which showed that in the acute stage symptomatic improvement occurred in the majority of cases within seventy-two hours with one treatment and that in the chronic cases three treatments at intervals of four weeks were necessary for relief. He also refers to Klein and Klemes's report of 25 patients with bursitis treated by roentgen rays, with only ten days of average disability, whereas for 25 patients treated by other means the average disability was fifty days.

In the discussion, Popp emphasizes that in calcareous deposits in bursae of the shoulder joint acute lesions respond more rapidly than chronic ones, and he states that roentgen ray treatment was applied in many instances at the Mayo clinic in both acute and chronic cases, with or without calcification, and that it is a safe and economical

740 Guido, F. R. Acute Calcified Subacromial or Subdeltoid Bursitis, *California & West. Med.* **60** 69-72 (Feb.) 1944

741 Pelner, L. Acute Subdeltoid Bursitis. Experiments with Iron Cacodylate, *Indust. Med.* **13** 826 (Oct.) 1944

742 Young, H. H. Calcified Bursitis, *Proc. Staff Meet., Mayo Clin.* **19** 250-253 (May 17) 1944

procedure even though the presence or absence of the calcareous deposits has no effect on the end results

Injuries and Disease of Acromioclavicular Joint—Oppenheimer⁷⁴³ states that roentgenograms show that there is motion in the acromioclavicular joint during all movements of the arm except pronation and supination. The technic of roentgenologic determination is described as well as the normal appearance of the joint. Mention is made of acromial fractures and acromioclavicular separations. Arthritis of this synovial or diarthrodial joint is discussed. The incidence, clinical manifestations and treatment are discussed, though few statistical data are given.

In the treatment of acute acromioclavicular separations, Wolin⁷⁴⁴ discusses the use of the modified Hunkin method of splinting acute acromioclavicular dislocations by the use of a body cast and straps over the affected shoulder to exert downward pressure on the clavicle. A torso cast is applied, allowing free use of the upper extremities, over a padded strap which runs over the shoulder and under the cast anteriorly and posteriorly and is long enough to be buckled over the shoulder again, thus exerting as much force as may be needed to reduce the dislocation. Four to six weeks of immobilization is necessary. The author treated 10 men with this method, with all returning to duty after an average time of six to eight weeks.

Giannestras⁷⁴⁵ presents a type of strap brace which he has found to work satisfactorily in reduction of a fresh separation of the acromioclavicular joint and maintenance of the reduction. The straps are arranged so that the downward pull from the weight of the extremity and the upward pull of the sternocleidomastoid muscle are counteracted. Straps go over the padded shoulder—one, a vertical strap, attached to the forearm just distally to the elbow with the arm at 90 degrees and the other enveloping the chest, running through the opposite axilla.

Birkett⁷⁴⁶ reports a case of acromioclavicular dislocation in a man aged 29 years, in whom not only were the ligaments of the acromion torn but the outer end of the clavicle was forced under and buried in the trapezius muscle, where it remained trapped. Open reduction and freeing of the clavicle were done, and a strip of fascia lata was used

743 Oppenheimer, A. Lesions of Acromioclavicular Joint Causing Pain and Disability of Shoulder, *Am J Roentgenol* **51** 699-706 (June) 1944

744 Wolin, I. Acute Acromioclavicular Dislocation. Simple Effective Method of Conservative Treatment, *J Bone & Joint Surg* **26** 589-592 (July) 1944

745 Giannestras, N. J. Method of Immobilization of Acute Acromioclavicular Separation, *J Bone & Joint Surg* **26** 597-599 (July) 1944

746 Birkett, A. N. Result of Operative Repair of Severe Acromioclavicular Dislocation, *Brit J Surg* **32** 103-105 (July) 1944

to fix the clavicle, acromion and coracoid process of the scapula. Reduction was satisfactory and motion good. The fascial strip became calcified in eight months.

Repair of Habitual Dislocation of the Shoulders—Several articles appeared in the Scandinavian journals dealing with the method of treatment of habitual dislocation of the shoulder. Ramser⁷⁴⁷ describes a technic first described in 1936, which, again, is based on the principal of Eden except that Ramser uses rustless steel for the blocking.

Brun⁷⁴⁸ recommends a procedure which is essentially that advocated by Eden and consists in the insertion of a tibial graft into the anterior rim of the glenoid. Brun has performed operation with the extra-articular graft method in 50 cases since 1931, 1 patient had a recurrence. In all other cases so far as he could follow them (he does not give the percentage of cases followed), there have been no recurrences.

Henderson⁷⁴⁹ presents the latest statistical reports on Henderson's suspension operation, comprising fifty-five tenosuspensions performed on 51 patients. The end results were 91 per cent successful in patients having been observed for more than one year. There are some points Henderson makes in regard to the causes of failure. First, in epileptic patients one should first control the convulsions, then, in regard to the technic, he emphasizes that the tendons should be long enough and tied under proper tension and a transplanted piece should be deeply placed close to the bone.

Injuries, Deformities and Diseases about the Neck—Chandler and Altenberg⁷⁵⁰ report an extensive study of torticollis. They stated the belief that the pathologic changes are limited to the sternocleidomastoid muscles and that the associated deformities of the face, head, ear and cervical portion of the spine are secondary. The changes may be present at birth or may not be noted until after the tenth to the fourteenth day, when a hard fusiform swelling is found in the sternocleidomastoid muscle. The delivery is usually abnormal and most usually a breech presentation. The swelling increases in size for two to three weeks, when it reaches the size of an almond. It then begins to regress, and it may be gone entirely in the course of four to five

747 Ramser, R. Treatment of the Habitual Dislocation of the Shoulder with a Metal Bar Anchored into the Neck of the Scapula and Coracoid Process, *Helvet. med. acta* **10** 377-380 (June) 1943.

748 Brun, H. Technique and End Results of the Extra-Articular Graft Plasty in Habitual Dislocation of the Shoulder, *Helvet. med. acta* **11** 495-500 (June) 1944.

749 Henderson, M. S. Tenosuspension Operation for Habitual Dislocation of the Shoulder, *Proc. Staff Meet., Mayo Clin.* **19** 5-10 (Jan. 12) 1944.

750 Chandler, F. A., and Altenberg, A. "Congenital" Muscular Torticollis, *J. A. M. A.* **125** 476-483 (June 17) 1944.

months The muscle feels short and hard and is noncontractile The head is tilted to the affected side, and the chin is rotated to the unaffected side Owing to the position of the head, it becomes foreshortened in the oblique fronto-occipital diameter The level of the eyes changes, the mastoid process becomes more prominent, and the clavicle and shoulder become elevated on the affected side A low cervical, high dorsal scoliosis may develop, with the convexity on the involved side

Gross Pathology The tumor is the fusiform swelling involving the whole muscle The size of the mass may be from 2 to 6 cm by 1 to 1.5 cm It is firm and has the texture of cartilage or fibrous tissue

There is replacement of muscle tissue by fibrous tissue The few muscle cells remaining show various stages of degeneration, with vacuolation and many nuclei, absence of striation and changes in their straining properties Some even show calcification Great masses of fibrous tissue and fibrocytes are present No hemorrhage is present As age progresses, nothing remains but fibrous tissue with nuclei in parallel rows

In order to clear up the anatomic basis for this condition, the authors injected veins and arteries of the neck in 5 stillborn fetuses They found that the sternocleidomastoid muscle was made of five to six muscle bellies (*a*) superficial sternomastoid, (*b*) superficial sterno-occipital, (*c*) superior cleido-occipital, (*d*) deep sternomastoid and (*e*) double deep cleidomastoid

Nerve supply is from somatic and visceral motor branches, though the motor branches come from the spinal accessory It also receives branches from the second, third and fourth cervical nerves

Blood Supply The occipital branch of the posterior auricular artery supplies the upper portion The sternomastoid artery or muscular branches from the occipital artery also supply the upper portion The sternomastoid branch of the thyroid artery supplies the middle and lower one third of the muscle The transverse scapular artery supplies the lower portion of the muscle The transverse cervical artery supplies the lower lateral portion

Veins The venous drainage of this muscle is into all the veins of the neck—interior and exterior jugular, anterior jugular, transverse scapular, occipital, posterior auricular and anterior and posterior facial veins

Etiologic Theories There are a number of theories of causation (1) abnormal pressure on head and neck during intrauterine life, (2) heredity (defective formation of the anlage of the sternocleidomastoid muscle), (3) neurogenic, (4) infection (no evidence to confirm it), (5) trauma during birth (the authors do not think the pathologic changes are due to hematoma), (6) ischemia of muscle during delivery, and (7) venous occlusion

The authors give a rather long but comprehensive summary of the possible causes of torticollis. These may be found in the original article. One hundred and one patients are reported. Early operation is advocated. [ED NOTE (L D B) —The reading of this report *in toto* is recommended.]

Basilar impression symptoms and roentgenologic findings in atlas and axis abnormalities are discussed by Saunders⁷⁵¹. This syndrome may mimic (1) syringomyelia, (2) progressive spastic paralysis, (3) shortening of the neck or (4) multiple sclerosis. Roentgenograms may show deformities of the foramen magnum, the base of the skull, the atlas and the axis, fusion of bodies of upper cervical vertebrae and fusion of the anterior arch of the atlas to the occipital bone. In addition, there may be a change in the relation of the axis, with the odontoid above its normal level, which level, he says, is a line joining the posterior margin of the hard palate and the dorsal margin of the foramen magnum. This line is called the "Chamberlain line".

The author took one hundred lateral roentgenograms of the skull to verify the presence of a basilar impression. He used the "Chamberlain line" as a basis and listed his findings positive or negative as to whether the odontoid was above or below the line. The normal odontoid is usually 1 mm below the line. When deviations are found above the line, especially several centimeters, the foramen magnum should be examined for abnormalities.

Custis and Verbrugghen⁷⁵² report on a case of basilar impression giving rise to symptoms indistinguishable from those of cerebellar tumor. They point out that this anomaly should be placed in the list of changes that must be ruled out in any patient in whom cerebellar tumor is suspected.

Wycis⁷⁵³ states that platybasia, although known for a long time, is just recently becoming an entity commonly recognized.

Two types of platybasia are described: primary, the result of congenital or developmental anomaly, and secondary, the result of softening and molding. Of the latter, rickets, osteomalacia, hyperparathyroid and osteitis deformans (Paget's disease) have been described as causative factors.

The author reports the first case of platybasia due to Paget's disease. There were severe neurologic manifestations. The symptoms

751 Saunders, W. W. Basilar Impression. Position of Normal Odontoid, *Radiology* **41**: 589-590 (Dec.) 1943.

752 Custis, D. L., and Verbrugghen, A. Basilar Impression Resembling Cerebellar Tumor. Case, *Arch Neurol & Psychiat* **52**: 412-415 (Nov.) 1944.

753 Wycis, H. T. Basilar Impression (Platybasia). Case Secondary to Advanced Paget's Disease with Severe Neurological Manifestations, Successful Surgical Result. *J Neurosurg* **1**: 299-305 (Sept.) 1944.

were relieved by high cervical laminectomy combined with suboccipital decompression

Heublein⁷⁵⁴ discusses various methods of aid in the diagnosis of traumatic lesions of the cervical portion of the spine. He discusses the use of the planograph and laminograph and states that they are of value in diagnosing pathologic fractures of the cervical portion of the spine. The laminograph is of importance in obliterating the shadow of metal braces or other orthopedic paraphernalia. The use of myelograms in the diagnosis of rupture of the cervical intervertebral disk is discussed. Heublein concludes that a thorough knowledge of the anatomy plus the proper roentgen technic is essential if accurate diagnosis of lesions of the cervical portion of the spine is to be obtained.

Injuries of the brachial plexus are discussed by Meadoff and Gray⁷⁵⁵. They present an outline of injuries of the brachial plexus under the headings of (1) traction injuries, (2) pressure injuries, (3) direct injuries, (4) toxic injuries, (5) lesions of the spinal cord and (6) hysteria. All the cases cited are industrial, taken from an orthopedic clinic at a shipyard.

Three cases of injury to the long thoracic nerve, 2 cases of injury to the scapular nerve and 1 case of combined injury to the suprascapular and the long thoracic nerve are cited. One case of post-operative injury to the brachial plexus is reported in which the arms were abducted to above head level while a compression fracture of the tenth dorsal vertebra was being reduced. Recovery was made except for some residual paresis of the deltoid muscle and 20 per cent winging of the scapula. Two cases of injury following dislocation of a shoulder, with no mention as to whether paralysis or paresis existed prior to reduction, are cited. One case of isolated injury to the axillary nerve by a fall is reported. One case of apparent avulsion of the roots of the brachial plexus is cited. This patient was treated by amputation of the extremity. One case of involvement of the long thoracic nerve and the suprascapular nerve following a serum reaction is reported. One case of bilateral involvement of the suprascapular and the axillary nerves as a result of arsenical poisoning is discussed. Meadoff and Gray suggest that the scalenus anticus syndrome is due to a stretch mechanism of the neurovascular bundle over the elevated first rib due to shortened scalenus anticus. The treatment in most of the cases was conservative, by means of physical therapy and faradic stimulation.

⁷⁵⁴ Heublein, G. W. Roentgen Diagnosis of Traumatic Lesions of Cervical Spine, *J. A. M. A.* **126** 950-954 (Dec. 9) 1944.

⁷⁵⁵ Meadoff, N., and Gray, A. B. Brachial Plexus Injuries, *Physiotherapy Rev.* **24** 10-18 (Jan.-Feb.) 1944.

Swank and Simeone⁷⁵⁶ review the anatomy of the scalenus muscle and its relation to the cervical nerves. They point out that the scalenus, in its origin by four tendinous slips, from the third, fourth, fifth and sixth cervical vertebrae, lies directly over the exit of the cervical nerves. The nerve below is usually the one affected, thus the fourth cervical nerve will cause symptoms by pressure from the third, the head of origin. They point out that the scalenus medius muscle gets a similar origin, only from the posterior tubercles of the transverse process. The brachial plexus lies between these two muscles. Under normal conditions there is enough space for the plexus, but hypertrophy or spasticity of these muscles along with a cervical rib or along the seventh cervical transverse process will cause pressure on the plexus. The lower segments of the plexus are those most affected, because those higher can accommodate themselves in the soft muscle belly.

Clinical Consideration There are two types: (1) the superior type, due to pressure on the upper, namely the sixth and seventh cervical roots, and (2) the inferior type, due to pressure on the eighth cervical and first dorsal roots.

The summary comprises 17 cases. In the superior type, the onset was sudden. There were sensory changes on the radial side of the hand and first, second and third fingers, weakness of the extensors of the fingers and wrist and pain, with muscle spasm of the shoulder, arm, forearm and neck. These symptoms may regress slightly and then recur. There may be wrist drop. There was also weakness of the flexors, pronators, supinators and the intrinsic muscles of the hand.

Another group complained of pain and muscle spasm, chiefly in the rhomboid, deltoid, triceps and teres major muscles and the extensors of the hand, wrist and fingers. The head was tilted to the affected side, and the shoulder was elevated. The muscles were tender, and small tender knots could be palpated. There was tenderness to pressure over the origin and insertion of the scalenus muscles.

Differential Diagnosis The condition should be differentiated from herniation of cervical disk.

Treatment Conservative treatment was first used. If this did not give relief, a tenotomy of the scalenus tendon was done.

Swank and Simeone describe the operation for scalenus anticus syndrome, which may be found in any textbook on surgery. They point out that the mechanism of pressure is similar to a vise, the upper end of the vise being a long transverse process or a cervical rib and the lower end being the scalenus anticus muscle. They support the theory of hypertrophy of the muscles through exercise. Often

⁷⁵⁶ Swank, R. L., and Simeone, F. A. Scalenus Anticus Syndrome: Types, Their Characterization, Diagnosis and Treatment, *Arch Neurol & Psychiat.* 51: 432-445 (May) 1944.

excessive breathing due to gunshot wounds of the lungs or pneumonia will cause hypertrophy of the scalenus muscles. A comprehensive study in detail is given at the end of this article.

Wartenberg⁷⁵⁷ discusses acroparesthesia, a syndrome with features of transient paresthesias, anesthetics, pain in the upper extremity at night, absence of any neurologic or orthopedic signs and a long, benign, self-limited course. The symptoms occur more often in women of 40 to 55 years and come on at night, when the patient is supine. The differential diagnosis is mentioned. Roentgenograms may reveal spondylarthritis or long cervical ribs. Spondylarthritis as a diagnosis is challenged. The author believes that muscular pressure on the brachial plexus is the cause of the nocturnal paresthesias. Ulnar nerve distribution of the symptoms is most frequently seen. The author mentions the work of Schultze on acroparesthesias and discusses the different conceptions of the syndrome.

An excellent study of cervical intervertebral disks based on 12 operative cases is presented by Spurling and Scoville⁷⁵⁸. Lateral herniation of a cervical disk was found in each patient, and all were relieved of their radiating pain within two weeks following operation. The authors draw an accurate clinical picture, which on the whole tallies with that recently published by Semmes and Murphy. The principal points of the symptom complex are as follows. Pain and stiffness of the neck are usually the first symptoms. Often the pain is brought on by certain movements of the neck, coughing, straining or sneezing. It is usually made worse by the maintenance of a single position, and the points of maximum pain are at the base of the neck, the tip of the shoulder and in the arm down to the elbow. Pain may extend to the hand, but the paresthesia and numbness in the hand are more annoying than is the pain. The whole hand goes to sleep, feels cold and appears bluish. Sensory deficits may not be demonstrated by the usual clinical tests in the beginning, but if the compression is prolonged a sensory deficit can usually be demonstrated.

Objective muscular weakness may be difficult to demonstrate, but the patients do complain that the involved extremity is weaker than normal. When weakness can be demonstrated, it has great diagnostic significance. The biceps muscle is supplied by the fifth and sixth root. Consequently, when weakness of the biceps with normal function of the triceps muscle occurs in a lesion of the sixth cervical root, there is a herniated disk between the fifth and sixth cervical vertebrae, while

757 Wartenberg, R. *Brachialgia Statica Paresthetica (Nocturnal Arm Dysesthesias)*, *J Nerv & Ment. Dis* 99 877-887 (May) 1944

758 Spurling, R. G., and Scoville, W. B. *Lateral Rupture of the Cervical Intervertebral Discs. Common Cause of Shoulder and Arm Pain*, *Surg., Gynec & Obst* 78 350-358 (April) 1944

a weak triceps and normal biceps muscles would indicate a lesion of the seventh cervical root, with a herniation of the disk between the sixth and seventh cervical vertebrae. Furthermore, the lesions at the fifth cervical disk are associated with diminution and absence of the biceps reflex, whereas lesions of the sixth cervical disk are associated with diminution or absence of the triceps reflex. These points are important contributions to what is already known about the distribution of sensory changes and paresthesias as described by Semmes and Murphy.

Other important observations are spinal tenderness at the site of the lesion and the so-called neck compression test. The latter is chiefly a reproduction of characteristic pain and radicular features when the head is tilted toward the painful side and pressure is exerted on top of the head.

Spurling and Scoville then proceed to clear an analysis of the differential diagnosis between protrusion of the intervertebral disk, neoplasm, compression of the scalenus anticus muscle, cervical arthritis and similar conditions.

Valuable evidence is given by roentgenologic examination. The lateral roentgenograms usually show narrowing of the involved interspace, with loss of the normal lordotic curve, even in hyperextended positions. The oblique views may show narrowing of the intervertebral foramina with proliferating osteophytes.

The myelographic examination with Pantopaque is an accurate method of diagnosing a ruptured disk. When the Pantopaque is injected (6 cc.) into the arachnoid space by lumbar puncture, the patient's head is fully extended by a small pillow placed under the chin before the table is tilted, so that the contrast material may not run into the basal cisternae of the skull. The head of the table is then tilted downward to permit the Pantopaque to collect in the cervical gutter. The defects are demonstrated by the writers in a number of roentgenograms.

Spurling and Scoville contend that conservative methods have an important place in the treatment, particularly if the symptoms are purely radicular and there is no evidence of compression. If the herniation is suspected to be a fairly large one, it is better to proceed with prompt operative intervention. The patients with milder disease may improve and may even get lasting relief by periods of rest in bed with halter traction. However, if after three or four days of this treatment there is no relief of either the radicular pain or the muscle spasm, then conservative treatment is useless. The authors are particularly against manipulation of the cervical portion of the spine.

After a description of the operative technic and postoperative treatment, the authors give the results as follows. The 12 patients operated

on were relieved of their radicular pain within two weeks following the operation, most of them earlier, and in each instance, with the exception of 1 case, the patient was able to return to military duties without disability

The ratio of the lesions of the lumbar and cervical ruptured disks is about 12 to 1, the authors finding twelve cervical and one hundred and forty-three lumbar ruptured disks, verified by operations, during the first eleven months of 1943

The distribution of pain between ruptures of the fifth and the sixth cervical disk is quite different. In the sixth cervical disk, the pain radiates from the neck into the shoulder and arm, with paresthesia at the posterior aspect of the thumb. There is always a weakness or absence of the tendon reflex of the biceps brachialis. In the sixth cervical disk, however, the pain radiates from the neck into the shoulder and arm, with paresthesia of the index, middle and perhaps ring fingers and the tip of the thumb. The symptoms are aggravated when the head is tilted to the painful side.

Bucy and Chenault⁷⁵⁹ present a case of herniated cervical intervertebral disk. The patient was injured when he fell on an icy street. The clinical syndrome consisted in repeated attacks of severe pain in the scapular region and persistent paresthesias of the thumb and index fingers and the radial border of the forearm. The herniation was confirmed surgically and found to have occurred between the sixth and seventh cervical vertebrae. After partial hemilaminectomy and excision of the disk, the patient had complete relief of symptoms.

Ulmer and Meredith⁷⁶⁰ report 3 cases of herniation of cervical intervertebral disks. The first 2 patients had lateral herniations of the seventh cervical disk, with compression of the eighth nerve root. Herniation was found at operation, and removal gave complete relief. 1 patient had precordial pain in addition to the radiating pain in the upper extremity. The third patient presented the neurologic picture of an extradural tumor of the spinal cord, with spastic paraplegia and subarachnoid block. This patient falls into Stookey's group of "syndrome of bilateral ventral pressure." At operation, the herniated disk was found and removed, with good results. The authors emphasize the importance of the "trigger point."

759 Bucy, P. C., and Chenault, H. Compression of Seventh Cervical Nerve Root by Herniation of Intervertebral Disk, *J. A. M. A.* **126** 26-27 (Sept 2) 1944

760 Ulmer, J. L., and Meredith, J. M. Syndrome of Cervical Root Compression and Brachial Neuritis Following Lateral Herniation of Intervertebral Disk, with Comment on Central Midline Protrusions, *Virginia M. Monthly* **71** 119-124 (March) 1944

Epstein and Davidoff⁷⁶¹ report on 5 patients who had verified herniated disks of the lower portion of the cervical part of the spine. The normal findings at myelographic examination with opaque oil in this region are described. Epstein and Davidoff feel that myelography of the cervical portion of the spine is a procedure which can provide valuable information. They express the opinion that it merits further study and evaluation. [ED NOTE (L D B) —The spinal canal in the cervical area is wide. A laterally placed disk may not be visualized in opaque myelograms.]

Peron, Lereboullet, Guillaume and Ribadeau Dumas⁷⁶² report the case of a 44 year old man who complained of pain in the right upper extremity followed by motor disturbance of the lower extremities. On examination there was a Brown-Sequard syndrome, hemiplegia of the leg and hemiparalysis of the arm on the right. On the left, there were sensory disturbances, which reached up to the fourth dorsal segment. A laminectomy was performed on the fifth, sixth and seventh cervical vertebrae. After the dura was opened, a herniated disk the size of a hazelnut was found and removed. Complete recovery followed, with the exception of the hypoesthesia on the left side. They also report on a 40 year old woman who complained of violent pain in the upper dorsal region, with radiation into the left arm, followed a month later by motor disturbances in the left lower extremity. The clinical examination showed the existence of the Brown-Sequard syndrome, motor changes on the left and sensory disturbances on the right. A laminectomy of the fifth and sixth cervical vertebrae demonstrated a herniated disk, which was removed. After the operation the symptoms disappeared except for slight defects in the left upper extremity and a persisting Babinski sign.

Management and Treatment of Injuries of the Jaw—Thoma⁷⁶³ presents an article reviewing the management and treatment of fractures of the jaw from World War I and World War II. This study should be of great interest to facial, maxillary and oral surgeons. Aside from the exhaustive presentation of former and present day methods in the management of fractures of the jaw, the most valu-

761 Epstein, B. S., and Davidoff, L. M. Iodized Oil Myelography of Cervical Spine, Observations on Normal and on Five Patients with Ruptured Intervertebral Discs of Lower Cervical Spine, *Am. J. Roentgenol.* **52** 253-260 (Sept.) 1944.

762 Peron, N., Lereboullet, J., Guillaume, J., and Ribadeau Dumas, C. Hernia of the Cervical Disc Producing Clinical Picture of Medullary Compression with Brown-Sequard Syndrome. Recovery After Operation, *Rev. neurol.* **74** 306-307 (Nov.-Dec.) 1942.

763 Thoma, K. H. History and Treatment of Jaw Fractures from World War I to World War II. Collective Review, *Internat. Abstr. Surg.* **78** 281-312, 1944, in *Surg., Gynec. & Obst.*, April 1944.

able contribution of the article is an imposing list of two hundred and fourteen references in the bibliography

A discussion of the incidence of the various sites of mandibular fractures and their treatment by wiring is presented by Merrifield ⁷⁶⁴ He describes, in not too great detail, the various types of maxillary and facial bone fractures and their treatment with various types of splints, such as the reversed Gunning splint, plaster head cap and wires For the fractures of the nasal bones, nasal packs with molding is advocated For the zygomatic fractures, Gillies' method is advocated

Sweet ⁷⁶⁵ emphasizes the importance of examination of the condylar neck in all fractures of the jaw, due to the fact that this fracture can be readily missed The technic consists of lateral views taken with the mouth open so that the central rays pass directly through the neck of the condyles He also elaborates on the type of film and times of exposure best suited

Strock ⁷⁶⁶ reviews the various methods of fixation of fractures of the mandible and presents a report on 2 patients treated as follows An incision is made over the fracture site, along the alveolar ridge, and the mucoperiosteum is reflexed to reveal the fracture site Burr holes are then made with a dental drill, and wires are passed through the holes and across the fracture site and cut off short Primary suture of the flap of periosteum and mucosa is then done [ED NORE (L D B)—It is difficult to maintain fixation of any fracture with wire]

The author feels that direct fixation is the method of choice in fractured edentulous mandibles when fractured fragments are accessible He states that the tissues in this area tolerate tantalum and ticonium

Van Zile ⁷⁶⁷ reports the use of a 10 gage iron wire coat hanger to apply traction as described by Erick The reason for the use of this substitute was the unavailability of the ready-made splint on shipboard The technic for making the appliance is described in detail

The indications for extraoral fixation of fractures of the mandible are discussed by Parker ⁷⁶⁸ The point emphasized is that it has its place in the treatment of fractures in which intraoral fixation is not possible or in which some function can be allowed if displacement is

764 Merrifield F W Management of Jaw Fractures, Radiology **41** 539-542 (Dec.) 1943

765 Sweet, A P S Radiology of Neck of Condyle, U S Nav M Bull **42** 1135-1139 (May) 1944

766 Strock, A E Inert Metals in Direct Fixation of Mandibular Fractures, Surg, Gynec & Obst **78** 527-532 (May) 1944

767 Van Zile, W N Technic for Building Head Cast Fracture Appliances from Coat Hangers, U S Nav M Bull **42** 200-207 (Jan) 1944

768 Parker, D B Skeletal Fixation in Treatment of Fractures of Mandible, S Clin North America **24** 381-391 (April) 1944

slight The appliances are all modifications of the Stader type of splint, using either threaded screws or pins In insertion of the pins or screws, a point near the angle of the jaw or the external oblique ridge is selected Resumption of chewing is not advised for the first few weeks The splint may be removed in five weeks unless there are contraindications The method is advisable for military personnel but not for civilian practice It has the disadvantages of increasing chances for infection and also of leaving scars [ED NOTE (L D B) —Physiologically, what is the difference between military personnel and civilians?]

Greeley and Thronson ⁷⁶⁹ report a case in which the placement of a Roger Anderson pin for fracture of the jaw injured the underlying facial artery and vein and was followed by the formation of an arteriovenous fistula, which later had to be removed The authors cite the case as a means of precaution in preventing the same occurrence in the future [ED NOTE (L D B) —An excellent way to prevent future occurrence is to discontinue the use of the pins] He advises care in all cases with pin fixation, with reference to injury to arteries and veins at the time of insertion

McLaren ⁷⁷⁰ describes a case of degeneration of the condyle of the left mandible in a man who had had repeated traumas to the jaw The area was resected, with good results

New and Erich ⁷⁷¹ point out that because of the frequency of facial maxillary injuries bone grafting of jaws will become a comparatively common procedure The authors describe the commonly known fact that bone grafts die and are subject to "creeping substitution" The two *sine qua non* factors for successful bone grafting of the jaw are absolute aseptic technic and a perfect fixation The authors describe a number of appliances for fixation of the fragments, depending on whether the jaw is or is not edentulous and depending on the number of teeth available for fixation They express general dissatisfaction with the vast majority of apparatus currently used

Donor sites for bone grafting of the jaw are the tibia, crest of the ilium, ribs and clavicle Sliding inlay grafts are also used

They claim that although experimental evidence shows that excess of bone marrow in grafts is detrimental to tissues about a bone graft, they prefer cancellous bone to compact bone In case of loss of soft tissue, this must be replaced before bone grafting is undertaken This article is excellent from the point of view of supplying technical details

769 Greeley, P W, and Thronson, A H Arteriovenous Aneurysm Resulting from Application of Roger Anderson Splint, J A M A **124** 1128 (April 15) 1944

770 McLaren, J W Bone Degeneration in Temporomandibular Joint Case Report, Brit. J Radiol **17** 94-95 (March) 1944

771 New, G B and Erich, J B Bone Grafts to Mandible, Am J Surg **63** 153-167 (Feb) 1944

XXII Research

PREPARED BY A. STEINDLER, M.D., IOWA CITY

Bone Growth Repair and Metabolism—The effects of ascorbic acid on the healing of fractures are discussed in an experimental study by Roche and Martin-Poggi.^{1,2}

As there is considerable difference of opinion among experimenters, it seemed appropriate to the authors to make new experimental studies in order to establish the role of vitamin C in the repair of fractures. Ashley Cooper called attention to the relation of the consolidation of fractures with absence of fresh food, and numerous authors have remarked on the absence of ascorbic acid and its adverse effect on callus formation. The action of ascorbic acid manifests itself principally in the formation of connective tissue in fractures and in the development of experimental granulomas. The experiments of the author have shown that the effect of ascorbic acid on the entire callus formation is as follows: 1 The organization of connective tissue matrix is influenced by ascorbic acid. 2 In the transformation of the connective tissue into the precallus formation as the preparatory stage to calcification, phosphatase plays the principal role. 3 In the formation of the bony callus itself the tricalcium phosphate plays a determining role.

In their experiments the authors made the following observations: 1 Lack of vitamin C produces in adult animals without fracture an absorption of bone. 2 In animals lacking vitamin C in which a fracture is produced, there is only a slight amount of connective tissue callus formed, the development of which stops rapidly and in a great number of cases becomes absorbed, so that the fragments are then united only by pseudarthrosis. 3 The lack of vitamin C in the rabbit causes considerable disturbance in the repair of fractures, while, in contrast, a fracture produced following a period of vitamin C privation will develop normally, with its initial absorption and increased high phosphatase development in the fragments, with consolidation as soon as vitamin C is added. Small quantities of ascorbic acid are sufficient. The authors obtained satisfactory results even with a daily dose of not more than 3 to 5 mg. Sometimes 1 or 2 mg. is sufficient for consolidation.

So far as the therapeutic application is concerned, it is evident that vitamin C is indicated only for persons with hypovitaminosis.

Since vitamin C has its effect only on the formation of connective tissues, its use, therefore, is indicated in the initial period of repair.

772 Roche, J., and Martin-Poggi, R. Effects of Ascorbic Acid. Experimental Studies, *J. de chir.* 58 264-269, 1941-1942

of fractures No improvement in calcification can be expected, but rather there will be an acceleration in the formation of connective tissue only

Blum⁷⁷³ presents a paper in which the purpose is twofold: to determine (1) whether phosphatase activity is affected by the presence of various organic and synthetic substances and (2) whether phosphatase could be used to accelerate the deposition of bone in an experimental fracture The inhibitory effect of many substances on phosphatase activity is described The use of phosphatase together with its substance, glycerophosphate and an anchoring medium of alginate gel accelerates bone repair Ectopic bone was formed in the muscle by the introduction of phosphatase, substrate and anchoring medium by injection

Bourne⁷⁷⁴ investigated the possible relationship between vitamin C and calcification in guinea pigs It has been previously stated that vitamin C plays no part in the production of bone salt but is essential for the laying down of the organic matrix of bone

The deposition of calcium in bone and the effect of vitamin C, vitamin P (citrin) and sodium citrate on such deposition are the subject of the experiments Also, the alkaline phosphatase activity in scurvy is investigated

Bourne shows that deposition of bone salt in normal and regenerating bone is retarded in scurvy, and this is corrected by addition of vitamin C The closely related citrus and sodium citrate play no part in this process

It is suggested that one of the functions of vitamin C is to allow production of a phosphatase-impregnated bone matrix

Class and Smith⁷⁷⁵ performed a series of experiments on 12 rats to determine the source of endogenous citric acid The end studies showed that the excess of citric acid excreted by the kidneys after the administration of sodium bicarbonate and sodium malate did not originate in the skeleton but was a product of intermediary metabolism This was a highly technical laboratory discussion

Silberberg, Atherton and Copher,⁷⁷⁶ in experimental observations, reveal that the administration of anterior pituitary extract accelerates the formation of cancellous bone occurring in the abdominal fascia

773 Blum, G Phosphatase and Repair of Fractures, *Lancet* **2** 75-78 (July 15) 1944

774 Bourne, G H Some Experiments on Possible Relationship Between Vitamin C and Calcification, *J Physiol* **102** 319-328 (Dec. 31) 1943

775 Class, R N, and Smith, A H Skeleton as Source of Endogenous Citric Acid, *J Biol Chem* **151** 363-368 (Dec.) 1943

around the transplants of urinary bladder in young dogs. This effect represents another instance of an acceleration of a tissue time curve by anterior hypophyseal hormone. The cartilage at the chondro-osseous junction of the ribs undergoes increased hypertrophy and regression under the influence of anterior pituitary extract, but its proliferation could not be stimulated in the young adult animals. The production as well as the resorption of bone could be temporarily increased by the hormone. The skeletal effects of the anterior pituitary extract in dogs are therefore similar to those exerted by this hormone in mice and guinea pigs.

The calcium-phosphorus and lead-phosphorus ratios in relation to deposition and absorption of lead have been investigated by Barrett.⁷⁷⁷ Growth was retarded but not stopped by the addition of lead to the diet. Addition of phosphorus to a basal leaded diet resulted in a reduction of the circulating lead and in a deposition of lead in the bone. Addition of calcium to the basal leaded diet caused an increase in ash weight, and the level of lead in the blood was maintained at the same level as with the basal leaded diet without calcium. Less lead is deposited in the bone if the calcium-phosphorus ratio is high.

Duckworth and Godden⁷⁷⁸ try to show that the increase in magnesium in bone ash which occurs in demineralization arises from a calcium-replacing action of magnesium. It does not occur if magnesium supplies are inadequate. If there is simultaneously a deficiency of calcium and magnesium, replacement does not occur. If after this period of calcium and magnesium starvation magnesium is restored to the body, then it begins to exert its calcium-sparing effect on the magnesium content of the skeleton. Although it may vary in bones, it does not vary in soft tissue.

The bioassay of the pituitary growth hormone by measurement of the width of the proximal epiphyseal cartilage at the tibia was suggested by Evans and colleagues (*Endocrinology* 32:13 [Jan] 1943). Marx, Simpson and Evans⁷⁷⁹ now make a comparison between this hormone and other purified anterior pituitary hormones other than the growth

776 Silberberg, M., Atherton, H. R., and Copher, G. H. Effects of Bovine Anterior Hypophyseal Extract on Urinary Bladder Transplants in Young Dogs, Including Some Observations on Its Effects on Endochondral Ossification, *Ann Surg* 120:680-688 (Oct) 1944.

777 Barrett, F. R. Studies on Deposition of Lead in Bone. Calcium-Phosphorus and Lead-Phosphorus Ratios, *M. J. Australia* 2:433-435 (Nov. 27) 1943.

778 Duckworth, J., and Godden, W. Replenishment of Depleted Skeletal Reserves of Magnesium, *Biochem. J.* 37:595-598, 1943.

779 Marx, W., Simpson, M. E., and Evans, H. M. Specificity of Epiphyseal Cartilage Test for Pituitary Growth Hormone, *Proc. Soc. Exper. Biol. & Med.* 55:250-252 (April) 1944.

hormone Adrenotrophic hormone decreased the width of the cartilage. The thyrotrophic hormone, the mammotrophic hormone and pure thyroxin increased the width of the epiphysial cartilage slightly after a considerable time, but definitely less than a single dose of the growth hormone

Sobel, Rockenmacher and Kramer⁷⁸⁰ report a scheme of analysis of bone for small samples which need to be in powder form It was desired to analyze the small bones of low ash content which were encountered in experiments on the composition of bone in young rats on experimental diets which produced rickets and poor growth Such bones, containing relatively large amounts of organic matter, are difficult to reduce to powder, which is necessary for most methods of carbonate analysis

The design of this scheme permits the various analyses to be made easily and precisely in a serial fashion on a single specimen weighing as little as 5 mg

Calcium may be determined in quantities as minute as 102, phosphorus in even smaller amounts, 352 of carbonate to 1 part in 1,000 and concentrations of lower than 0.02 milliequivalents of total base, with less than 2 per cent error

The authors discuss the various technics used

Martin⁷⁸¹ reports on the clinical use of bone meal in doses of 20 grains (1.2 Gm) daily in conjunction with minimum requirements of vitamins A and D, given to 57 children complaining of "growing pains"

whose parents stated that he or she kicked and screamed in the night" A similar number of patients were put on dicalcium phosphate All the children on bone meal had complete remission of symptoms, while of those on dicalcium phosphate 35 still had complaints After these were placed on bone meal, their symptoms disappeared Martin reports that bone meal prevented leg cramps and dental cavities in pregnant women Their babies had remarkably long finger nails and long silky hair and were healthy Martin also uses bone meal for muscular cramps in both sedentary workers and laborers

Sympathetic block in crush injuries is discussed by Thomson, Helwig and Sire⁷⁸² They report on the objective physical and histopathologic observations made in over 100 experimental animals (albino rabbits), which were killed one hundred hours after severe crush fractures of the

780 Sobel, A. E., Rockenmacher, M., and Kramer, B. Microestimation of Inorganic Constituents of Bone, *J. Biol. Chem.* **152**: 255-266 (Feb.) 1944

781 Martin, E. M. Report on Clinical Use of Bone Meal, *Canad. M. A. J.* **50**: 562-563 (June) 1944

782 Thomson, J. E. M., Helwig, F. C., and Sire, E. Sympathetic Block in Treatment of Local Shock. Experimental Study, *J. Bone & Joint Surg.* **26**: 189-196 (Jan.) 1944

right humerus in the midshaft Four hours after the injury, one half of these animals received injections of 3 cc of procaine hydrochloride (2 per cent) into the region of the right stellate ganglion The remainder of the animals were used as controls and had no treatment All of them were observed regularly at frequent intervals, and changes in temperature of both right and left upper extremities and evidence of swelling were recorded Finally, at the end of one hundred hours, the animals were killed, the right upper extremities were amputated at the shoulder, and sections were taken of the tissue in the region of greatest injury From these observations, it was concluded that procaine block of the sympathetic vasoconstricting mechanism in the severely injured extremities of experimental animals tends to restore the normal circulatory integrity to the extremity It stimulates a more normal interchange of tissue fluids and excites capillary activity to carry away rapidly the tissue products after trauma These experiments would seem to indicate that the blocking of the vasoconstriction sympathetic mechanism should be more frequently resorted to as an early therapeutic measure in the treatment of severely crushed extremities

Inman and Saunders⁷⁸³ investigated the threshold of sensitivity to painful stimuli of the various deeper structures in order to clarify the question of referred pain from skeletal structures This was done qualitatively by introduction of needles, drilling with a Mathews wire and injection of weak solutions of formic acid and hypertonic solution of sodium chloride and quantitatively by the injection of buffered salt solution under known pressures In a total of one hundred and sixty observations on 26 subjects it was found that the localization of pain produced by stimuli to the more deeply placed structures was increasingly poor Periosteum had the lowest threshold of pain, followed in order by the ligaments, fibrous capsules of joints, tendons, fascia and, the least sensitive, muscle Stimulation of the periosteum, ligaments and tendons caused extensive radiation of pain Often pain is accompanied with severe vasomotor reactions The radiating pain is similar to the pain produced at the point of stimulation except that there is a time lag of several minutes to several hours The pain also is continuous along the path of its radiation Stimulation of the same anatomic structure, whether it be periosteum, fascia or other structure, always results in radiation along the same path and in the same direction The pain may radiate distally or proximally and may persist for several days with exacerbation after even slight trauma Because of the constancy in radiation, the authors mapped out areas to which the pain radiates and they call these areas the "sclerotomes", these differ from the

783 Inman, V T, and Saunders, J B deC M Referred Pain from Skeletal Structures *J Nerv & Ment Dis* 99 660-667 (May) 1944

dermatomes in distribution. A series of the various "sclerotomes" and dermatomes are pictured by Inman and Saunders. They suggest that pain from the deeper structures has no superficial cutaneous component and is not related to irritation of any major peripheral nerve. It is proposed that an obscure reflex mechanism brings about radiation of pain from the deep mesodermal structures, and the pathways are designated by the term "sclerotome."

Blalock⁷⁸⁴ presents data (on trauma to tissues) from experimental work on animals. In one group, the application of the tourniquet was continuous during the experiment, whereas in the other it was intermittent. Before the tourniquet was applied, the extremity was repeatedly traumatized. In one of the groups the tourniquet was left in place for five hours, whereas in the other group the tourniquet was released for two minutes every thirty minutes. Of the first group, only 1 survived. In the second group, in which the tourniquet was released intermittently, 8 survived. Blalock offers this evidence as support to confirm the prevailing impression regarding the dangers associated with the prolonged use of a tourniquet on an injured extremity.

Muscles—The effects of passive and active exercise on muscle tonus were investigated by Fries⁷⁸⁵. Active and passive exercise of specific muscle groups, by means of a special motor-driven ergometer bicycle, in 11 normal women was tested by a modified Martin strength test before and after twenty-one days of training. A short period of systematized daily training will produce a demonstrable increase in strength of these muscle groups, which are made to develop active tension during exercise. Purely passive exercise does not cause any significant change in muscle strength. It is suggested that there may be a physiologic relationship between muscle soreness during training and the subsequent increase in muscle strength.

Unna and Pick⁷⁸⁶ state that thiamine hydrochloride in concentrations of 10 to 15 mg per hundred cubic centimeters prevents the effect of nicotine on the isolated intestine of rabbits and guinea pigs and on the isolated skeletal muscle of the frog. The authors found that neostigmine does not counteract this effect. Thiamine only temporarily blocks the action of nicotine but does not permanently damage the ganglions. The inhibitory effect of thiamine is confined to the synapsis and to

784 Blalock, A. Effects of Continuous and of Intermittent Application of Tourniquet to Traumatized Extremity. *Arch Surg* **48** 489-490 (June) 1944.

785 Fries, E. C. Some Physiologic Effects of Passive and Active Exercise Training Effects on Strength of Specific Muscle Groups, *Arch Phys Therapy* **25** 546-549 (Sept) 1944.

786 Unna, K., and Pick, E. P. Inhibition of Nervous Transmission in Synapses and End Plates by Thiamine, *J Pharmacol & Exper Therap* **81** 294-300 (July) 1944.

the receptive apparatus of the end plates at the myoneural junction. The other B vitamins, such as riboflavin, pyridoxine, pantothenic acid, nicotinamide and paraaminobenzoic acid, do not have the same effect on the action of nicotine. The effect of thiamine is linked to the thiazole structure of the molecule.

Thomsen and Luco⁷⁸⁷ discuss the changes of weight and neuromuscular transmission in muscles of immobilized joints. The influence of fixation of the tibiotarsal joint on the neuromuscular synapse and the weight of the soleus and tibialis anticus muscles was studied on cats anesthetized with pentobarbital sodium. The joint was fixed in hyperflexion and hyperextension and in a position intermediate between these two. After immobilization in these three positions, these muscles show the same changes in neuromuscular transmission as are found in the tenotomized muscles. At high frequency of stimulation, there was a greater development of the third stage of neuromuscular fatigue, in relation to the first stage, than occurred in the central muscles. The immobilized muscle resembles tenotomized muscles also in being less sensitive to curare. Fixation in hyperflexion up to fourteen days causes an increase in the weight of the soleus and a decrease in the weight of the tibialis, fixation in hyperextension causes a decrease in the weight of the soleus and an increase in the weight of the tibialis. In the discussion, the hypothesis is presented that in immobilization, as in tenotomy, the abnormal tension to which muscle is exposed causes neuromuscular changes by a reflex mechanism.

Phosphorus Metabolism—Bollman and Flock⁷⁸⁸ present experiments to show that the changes in the phosphates of muscle after tourniquet shock are those of autolyzing muscle. Adenosine triphosphate almost disappears after three hours, and phosphocreatine is almost completely hydrolyzed in one hour. The inorganic phosphates of muscle rapidly increase to a maximum in about four hours. The total of the acid-soluble phosphates is not changed. If blood flow is restored within three hours, there is resynthesis of adenosine triphosphate and phosphocreatine and a decrease in inorganic phosphates. Fatal shock does not develop even if large amounts of muscle have been occluded.

Sacks⁷⁸⁹ studied the effects of prolonged activity, recovery from activity and administration of glucose on the metabolism of phosphorus compounds of muscle, using radioactive phosphorus as a tracer substance.

787 Thomsen, P, and Luco, J. V. Changes of Weight and Neuromuscular Transmission in Muscles of Immobilized Joints, *J Neurophysiol* 7 245-251 (July) 1944

788 Bollman, J. L., and Flock, E. V. Changes in Phosphate of Muscle During Tourniquet Shock, *Am J Physiol* 142 290-297 (Sept.) 1944

789, Sacks, J. Some Factors Influencing Phosphate Turnover in Muscle, *Am J Physiol* 142 621-626 (Nov.) 1944

The principal observations were that prolonged activity does not influence either the uptake of radioactive phosphorus or its distribution between the various phosphorus compounds. Recovery from such activity does increase the turnover of phosphorus significantly, especially in the post-absorptive state. The administration of glucose to the animal in a post-absorptive state depresses the turnover of phosphocreatine and adenosine triphosphate but does not influence the turnover of glucose-6-phosphate.

Meyer and Meyer⁷⁹⁰ attempted a study on the exact nature of vitamin C deficiency on inflammatory conditions. The pathologic processes involved in the healing of staphylococcic abscesses in scorbutic guinea pigs were found to be quite different from those in normal control animals. In the initial reaction surrounding the inoculation, the appearance of macrophages was normal. However, more bacteria appeared to be extracellular in the abscesses one, three and seven days after inoculation in the scorbutic animals than in the controls. The connective tissue reaction in the healing of sterile incisions was similar to that described by other workers. Proliferation of fibroblasts continued after it had ceased in the control animals, and no normal collagen was formed. The connective tissue and the abnormal hyalin-like intercellular substance which was formed were disorderly in arrangement, and the necrotic centers of the abscesses were not walled off. Studies of the blood showed anemia and low serum proteins in the scorbutic animals.

A preliminary report on the effect of roentgen rays on joints is presented by Horwitz and Dillman⁷⁹¹. Six patients with nonspecific effusion of the joints involving the knee joint in human beings were treated by roentgen rays. Eight of the 9 patients responded favorably. In 3 cases biopsy of synovial membrane was done prior to treatment and in 2 cases after the treatment. There was disappearance of edema, a diffuse fibrosis and a thickening of the lumens of the smaller blood vessels. No tissue degeneration was noted. The effect of radiation in normal joints of dogs was studied, and there were no immediate untoward results. The authors will analyze the delayed effect of roentgen rays in subsequent reports.

Thrombin—Ingraham and Bailey⁷⁹² discuss the two products thus far prepared from the purified fractions of human fibrinogen and throm-

790 Meyer, E, and Meyer, M. B. Pathology of Staphylococcus Abscesses in Vitamin C-Deficient Guinea Pigs, *Bull. Johns Hopkins Hosp.* **74** 98-117 (Feb.) 1944.

791 Horwitz, T, and Dillman, M. A. Effect of Roentgen Rays on Joint Effusions in Certain Nonspecific Articular Lesions in Humans, and on Normal Joints of Dogs. Preliminary Report, *Am. J. Roentgenol.* **51** 186-201 (Feb.) 1944.

792 Ingraham, F. D., and Bailey, O. T. Clinical Use of Products of Human Plasma Fractionation. Use of Products of Fibrinogen and Thrombin in Surgery, *J. A. M. A.* **126** 680-685 (Nov. 11) 1944.

bin and their several uses fibrin foam, which is used with a solution of thrombin as an absorbable hemostatic agent, and fibrin film, which has been used as a dural substitute and in the prevention of meningo-cerebral adhesions Extensive clinical use of fibrin foam in neurosurgical and general surgical problems, including hemophilia, is discussed The authors also discuss the limited use of solutions of fibrinogen and thrombin in special situations in which clot *in situ* is desirable Method and ease of application are discussed

Preface

IN THE preparation of this review of orthopedic surgery for 1944 the titles of 1,434 articles of orthopedic interest were selected from the *Quarterly Cumulative Index Medicus* for 1944 The number of articles reviewed and presented in this year's "Progress" is 821 This is a larger number of articles than that selected for 1943 but is still below the average for previous years The increase in the number of articles over that of 1943 is due to the increase in the number of reports from the general hospitals of the armed services As in the past, each editor has selected the articles for his section which he thinks represent the most progress and have the greatest scientific interest The chairman of the editorial board has reviewed the material prepared for each section and has made certain additions and changes which seemed indicated to standardize the publications

On account of the difficulties under which many of the editors have been working, the reviews of some of the sections have been slower in being returned to the chairman of the editorial board, and, as was true in the past two years, it was found impossible to send the whole "Progress" to the ARCHIVES at one time This has necessitated a slight change in the order of publication of the sections The preface could not be written until all sections had been submitted In spite of the difficulties encountered in getting reprints it is hoped that the quality of the reviews is up to standard and that the publication will prove as valuable to its readers as the "Progress" of previous years

The members of the editorial board wish to thank again the physicians not members of the American Academy of Orthopaedic Surgeons who have rendered such valuable assistance in the preparation of the material for the various sections

Special thanks are rendered to Dr J A Toomey, of Cleveland for editing the research portion of the section on "Poliomyelitis" and to Dr Robert L Bennett of Warm Springs Ga for editing the physical therapy portion of the section on "Poliomyelitis"

The following physicians acted as assistants to members of the editorial board

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Both style and editorial comments have again been left to the discretion of the editors except for a few changes made by the chairman. It should be stated again, however, as in the preface of the "Progress" of previous years "If the reader or author of any article does not agree with the editorial comment, the editorial board hopes that he will think of the remark as only one man's impression and as in no way representing the opinion of the entire editorial board" or of the American Academy of Orthopaedic Surgeons

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STREPTOMYCIN IN THE TREATMENT OF SURGICAL INFECTIONS

Report of Experiences with Its Use

JOHN WINSLOW HIRSHFELD, M D
ITHACA, N Y

AND

CHARLES W BUGGS, Ph D, MATTHEW A PILLING, M D,
BERNICE BRONSTEIN, M S

AND

CHARLES H O'DONNELL, M D
DETROIT

With the technical assistance of Louie J Key, R N, and Lucille Worzniak, M T

SURGEONS are called on to treat a number of infections which do not respond to the usual surgical measures or to the forms of chemotherapy that have been available. They are frequently complicated by the presence of intestinal fistulas, intestinal obstruction, urinary obstruction, pieces of dead bone, necrotic fascia or tendon and poor blood supply. Because of these factors and because several types of bacteria are usually present, it is difficult to compare these infections with one another or to classify them for purposes of evaluating therapy. In these respects, they differ significantly from such diseases as pneumococcic pneumonia, meningococcic meningitis, typhoid and gonococcic urethritis, all of which have a simple etiologic agent and run a fairly typical course.

Examples of these infections can be found in any surgical service. They are usually difficult to treat, often persisting for many weeks. For these reasons it is important to search for new methods of treatment and, in spite of the difficulties involved, to attempt to evaluate such new methods.

The new antibiotic, streptomycin, is known from the results of both *in vitro* and *in vivo* experiments¹ to be effective against many

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Aided by grants from Merck & Co, Inc., Rahway, N J, and by the Theodore A McGraw Fund.

1 Feldman, W H, and Hinshaw, H C. Effects of Streptomycin on Experimental Tuberculosis in Guinea Pigs. A Preliminary Report. Proc Staff Meet Mayo Clin 19 593-599, 1944. Heilman, F R. Streptomycin in the Treatment of Experimental Tularemia, *ibid* 19 553-559, 1944. Streptomycin in the Treatment of

(Footnote continued on next page)

gram-negative and gram-positive bacteria. Since most of the infections under discussion are caused by a mixture of gram-positive and gram-negative organisms, it is important to test the efficacy of streptomycin in their treatment. The purpose of this paper is to present the results of treatment of 55 such infections with streptomycin.

MATERIALS AND METHODS

Streptomycin hydrochloride was supplied by the manufacturer in sealed rubber-capped bottles.² The manufacturer's assay value was accepted, and for systemic administration the material was dissolved in sterile isotonic solution of sodium chloride to make concentrations of 10,000 to 100,000 S units³ per cubic centimeter. The solutions were prepared just before use. Streptomycin was customarily given intramuscularly, either by intermittent injection or as a continuous infusion. In a few instances, it was given intravenously as a continuous infusion in concentrations of 1,000 S units per cubic centimeter of isotonic solution of sodium chloride. For local use in wounds, concentrations from 250 to 1,000 S units per cubic centimeter were employed. The material was usually applied as a slow continuous drip through a small rubber tube incorporated in the dressing. Frequent samples of blood were withdrawn from patients who received streptomycin systemically, and the concentration of streptomycin in the serum was determined by the cup plate method of Stebbins and Robinson.⁴ Whenever feasible, the causative organisms were isolated and their *in vitro* resistance to streptomycin was determined.

RESULTS

Bacteremia—Nine patients with bacteremia were treated (table 1). In 5 instances, treatment was successful in that the blood stream was sterilized and the patient recovered. In 3 instances treatment failed,

Experimental Infections with Micro-organisms of the Friedländer Group (*Klebsiella*), *ibid* **20** 33-39, 1945. Jones, D., Metzger, H. J., Schatz, A., and Waksman, S. A. Control of Gram-Negative Bacteria in Experimental Animals by Streptomycin, *Science* **100** 103-105, 1944. Robinson, H. J., Smith, D. G., and Graessle, O. E. Chemotherapeutic Properties of Streptomycin, *Proc. Soc. Exper. Biol. & Med.* **57** 226-231, 1944. Schatz, A., Bugie, E., and Waksman, S. A. Streptomycin a Substance Exhibiting Antibiotic Activity Against Gram-Positive and Gram-Negative Bacteria, *ibid* **55** 66-69, 1944. Schatz, A., and Waksman, S. A. Effect of Streptomycin and Other Antibiotic Substances upon *Mycobacterium tuberculosis* and Related Organisms, *ibid* **57** 244-248, 1944. Waksman, S. A., and Reilly, H. C. Bactericidal Action of Antibiotic Substances, *J. Infect. Dis.* **75** 150-159, 1944. Waksman, S. A., Bugie, E., and Schatz, A. Isolation of Antibiotic Substances from Soil Micro-organisms, with Special Reference to Streptothricin and Streptomycin, *Proc. Staff Meet., Mayo Clin.* **19** 537-548, 1944.

2 Dr. D. F. Robertson, of Merck & Co., Inc., Rahway, N. J., supplied the streptomycin.

3 An Esch. coli, or S, unit of streptomycin is that quantity which when dissolved in 1 cc. of nutrient broth or agar will just suffice to inhibit the growth of a given strain of *Escherichia coli*. Waksman, S. A. Standardization of Streptomycin, *Science* **102** 40-41 (July 13) 1945.

4 Stebbins, R. B., and Robinson, H. J. A Method for Determination of Streptomycin in Body Fluids, *Proc. Soc. Exper. Biol. & Med.* **59** 255-257, 1945.

TABLE 1—*Effects of Streptomycin in Cases of Bacteremia*

Patient	Source of Infection	Bacteria Recovered	Resistance In Vitro, Units/Cc	Dose and Route of Administration	Serum Level, Units per Cc	Other Therapy	Results
S W	Suppurative arthritis	H influenzae	Not done	50,000 units every 3 hr intramuscularly for 87 doses, discontinued for 5 days started again 250,000 units every 3 hr intramuscularly for 31 doses	After 1st dose 1 hr 0.875, 2 hr 0.44, 3 hr 0.44 after 7th dose 3 hr 0.44		Blood sterile after 2 doses but joints remained swollen and patient did not improve, blood culture positive 24 hr after 1st course of therapy ended, blood positive all through 2d course, patient later cured with sulfadiazine
K L	Sinusitis	Staph albus	256	1,000,000 units every 6 hr intramuscularly for 42 doses 6,000,000 units daily as continuous intramuscular infusion for 5 days	After 42d dose 4 hr 88, during dose of 44th million about 100.4, 2 hr after therapy was discontinued about 112	Penicillin, sulfathiazole	Failure, multiple pulmonary abscesses and cavernous sinus thrombosis
S V	Unknown	K pneu moniae	0.25	1,000,000 units every 6 hr intramuscularly for 7 doses, 500,000 units every 6 hr for 16 doses	Not done	Sulfathiazole	Cure
L L	Infection of urinary tract	A aerogenes	3	2,000,000 units per 24 hr continuous intravenous infusion for 3 days	15.2 at end of 24 hr of therapy		Cure
W T	Infection of urinary tract and wound	A aerogenes	2	500,000 units every 6 hr intramuscularly for 24 doses	After 1st dose 2 hr 7, 4 hr 28, 6 hr 3.6, after 24th dose 2 hr 47.6 4 hr 88.3		Patient recovered blood stream sterilized rapidly, but wound abscess drained on 6th day of therapy contained alpha hemolytic streptococci, A aerogenes, Esch coli, sensitive to 8, 2 and 16 units of streptomycin per cubic centimeter respectively
R. H	Urinary infection	Esch coli	Not done	1,000,000 units every 6 hr intramuscularly for 12 doses 500,000 units every 6 hr for 12 doses	After 1st dose 1 hr 19.4, 2 hr 21.4 4 hr 31.6 hr 20.2 after 6th dose 6 hr 23.6, after 16th dose 6 hr 13.6		Cure
K I	Diabetic gangrene of foot	Esch coli	32	500,000 units every 6 hr intramuscularly for 20 doses			Infection of blood stream cured, but other organisms in urine, namely A. aerogenes and Str. viridans which were extremely resistant, persisted
A D	Ruptured appendix	Esch coli	5	2,000,000 units per 24 hr as continuous intravenous infusion for 30 hr then 1,000,000 units every 6 hr intramuscularly for 6 doses	After 1st intramuscular dose 6 hr 95.6 after 2d intramuscular dose 1 hr 77.6 2 hr 71.2 4 hr 80.8 6 hr 65.6 after dose of 5th million 4 hr 95.2		Patient died, autopsy showed extensive peritonitis, multiple hepatic abscesses and pyelophlebitis, B coli recovered from the abscesses
A O	Pyelitis	Esch coli	40	1,000,000 units every 6 hr intramuscularly for 8 doses stopped for 24 hr because of reaction, then 1,000,000 units every 6 hr for 7 doses	After 1st dose 6 hr 40, after 1st dose of second course 6 hr 114.5		Patient in critical condition when therapy started blood promptly sterilized but patient became stuporous 2 hr after receiving 8th dose of 1,000,000 S units blood pressure 80/20, therapy resumed after 24 hr but patient died after 7,000,000 units, autopsy revealed cirrhosis of liver and pyelonephritis

and in 1 instance (A G) the patient died in spite of sterilization of her blood. The cause of death in this case is uncertain. The patient became comatose after receiving 8,000,000 S units of streptomycin over a forty-eight hour period. Therapy was discontinued, and during the ensuing twenty-four hours the condition of the patient improved. Therapy was started again, but the patient gradually failed, and she died after receiving an additional 7,000,000 S units over forty-two hours. Autopsy revealed cirrhosis of the liver and pyelonephritis.

An analysis of these cases reveals that although streptomycin sterilizes the blood promptly it does not sterilize walled-off collections of pus (patients W T and A D), even though a serum concentration of streptomycin is present which, on the basis of *in vitro* tests, is more than adequate to inhibit growth of the organisms in the abscess. The following case illustrates this point.

W T, a white man, 41 years of age, had had the left kidney removed a number of years ago. Shortly before he consulted us a stone became impacted in the right ureter, and on March 9, 1945 he was examined by means of a cystoscope and a catheter was passed to the right renal pelvis. The day of cystoscopy chills and fever developed and the patient became extremely ill. During the next few days, in spite of penicillin therapy and an adequate urinary output, he failed to improve. On March 16 the stone was removed surgically. Chills and fever persisted, the man became critically ill and on March 21, and again on March 22, *Aerobacter aerogenes* was recovered from his blood stream. Streptomycin therapy was initiated on March 22 in doses of 500,000 S units intramuscularly every six hours and continued until March 28, a total of 12,000,000 S units being given. *In vitro* the organism was inhibited by 2 units of streptomycin per cubic centimeter. The concentration of streptomycin in the patient's serum was as follows:

	Time After Dose, Hr	Units per Cc of Serum
First dose	2	7.0
	4	28.0
	6	8.5
Second dose	2	47.5
	4	38.3

After one day of treatment, the temperature, which had varied from 97 to 104 F, leveled off at 100 to 100.5 F, and subsequent blood cultures were sterile. On March 27, the sixth day of therapy, a small abscess in the wound was drained. The temperature fell to normal the following day and remained so. Streptomycin was discontinued on March 28. The following organisms were recovered from the wound abscess:

	<i>In Vitro Sensitivity to Streptomycin Units per Cc</i>
Alpha hemolytic streptococci	8
<i>Aerobacter aerogenes</i>	2
<i>Escherichia coli</i>	16

In spite of the fact that all these organisms were inhibited *in vitro* by concentrations of streptomycin less than the patient presumably had in his serum during most of his therapy, they were not killed but persisted and caused fever until the abscess was drained.

Peritonitis—Streptomycin was administered to 12 patients with peritonitis, caused in 5 instances by perforation of the appendix, in 6 by rupture of a peptic ulcer and in 1 by a perforation of a carcinoma of the cecum. The results of therapy in these cases (table 2) are difficult to assess. First, peritonitis is an unpredictable disease. Some patients who appear critically ill recover with surprising rapidity, while others, who at first do not seem as sick, may die or recover only after a protracted illness. Second, the bacterial flora in peritonitis is usually complex, and often all the offending organisms are not recovered by the usual methods of culture. Third, some of the patients in cases reported in this paper had penicillin or sulfadiazine in addition to streptomycin, because the surgeons in charge were reluctant to withhold any treatment which might be of benefit to a patient who was critically ill.

Because of the reasons listed, it is unwise to conclude a great deal from this small group. It is apparent, however, that in these cases streptomycin had no spectacular effect. The patients with peritonitis resulting from perforation of the appendix followed the course that one was accustomed to observe before the advent of chemotherapy. One patient with generalized peritonitis who had been sick for three days recovered after nineteen days. Another, who had been ill for only two days, recovered after six days. In this instance, however, the peritonitis was rather mild. Pus which was aspirated from the peritoneum yielded only *Staphylococcus albus*, diphtheroid bacilli and nonhemolytic streptococci. In a third patient, who was also treated conservatively, a pelvic abscess formed but the patient finally recovered, after twenty-four days. In a fourth patient (A. D.), who was reported in the group with septicemia, pyelophlebitis with hepatic abscess developed and the patient finally died. It should be observed that in this instance streptomycin therapy was not instituted until the patient was almost moribund. The pyelophlebitis and hepatic abscess were probably already present. None of these patients were operated on. The fifth patient, a girl 14 years of age, had an appendectomy after the appendix had perforated. In spite of treatment with streptomycin an infection of the wound and a pelvic abscess developed, but the patient recovered after about three weeks. Similarly, the patients in whom peritonitis was the result of perforation of a peptic ulcer did not recover spectacularly under treatment. The patient whose peritonitis was due to perforation of a carcinoma of the cecum had been ill for ten months and was admitted to the hospital with a large intra-abdominal abscess. A fecal fistula followed drainage of the abscess. Although the patient's general condition was so poor that further intervention was not warranted, an ileotransverse colostomy was done. It was discovered at this operation that the patient had a plastic peritonitis. In spite of vigorous strepto-

TABLE 2—Effects of Streptomycin in Cases of Peritonitis

Patient	Source of Infection	Bacteria Recovered	Resistance In Vitro, Units/Cc.	Dose and Route of Administration	Serum Level Units per Cc	Other Therapy	Results
F B	Appendicitis, appendectomy	Aerogenes Esch coli Alpha hemolytic streptococci	3 5 —	1,000,000 units every 6 hr intramuscularly for 26 doses	After 1st dose 2 hr 36 0 4 hr 22.5, 6 hr 17 4 after 7th dose 2 hr 48, 4 hr 25, 6 hr 20 4 after 11th dose 2 hr 48 4, 4 hr 42 6 hr 24 4	None	Recovery after 3 wk pelvic abscess developed which subsided without drainage and wound infection containing Aerogenes resistant to 5 units per cc alpha streptococci resistant to 16 units per cc B melaninogenicus and unidentified gram negative rod
H M	Appendicitis, no operation	Esch coli Ps aeruginosa A. aerogenes	6 41 5	250,000 units every 6 hr intramuscularly for 43 doses		Penicillin 15,000 units every 3 hr neously intramuscularly for 50 doses	Recovery after 24 days pelvic abscess developed, which subsided spontaneously
T D	Appendicitis, no operation	Esch coli Gram negative rods, unidentified Bacteroides melaninogenicus, anaerobic gram positive coccus, anaerobic streptococci	4 32	1,000,000 units every 4 hr for 19 doses, then every 6 hr for 4 doses intramuscularly		Penicillin	Recovery after 19 days
C B	Appendicitis, no operation	Staph albus, diphtheroid, gamma streptococci		1,000,000 units every 6 hr for 20 doses intramuscularly		Penicillin 15,000 units every 3 hr	Recovery temperature elevated 6 days
A D	Appendicitis, no operation	Esch coli	5	2,000,000 units per 24 hr continuous intravenous infusion for 1½ days, then 1,000,000 units every 6 hr for 5 doses	After 1st dose intramuscularly, 6 hr 65 0, after 2d dose intramuscularly 1 hr 77 0, 2 hr 71 2, 4 hr 80 8, 6 hr 65 0, after 5th dose intramuscularly 4 hr 95 2		Death, autopsy showed extensive peritonitis, pyelophlebitis and liver abscess

A O	Peptic ulcer perforated	Alpha hemolytic streptococci	1,000,000 units every 6 hr intramuscularly for 16 doses	Penicillin 15,000 units every 3 hr	Temperature elevated for 7 days recovery
E P	Perforated ulcer	Anaerobic coccus, alpha hemolytic streptococci	1,000,000 units every 6 hr intramuscularly for 17 doses	Penicillin 15,000 units every 3 hr	Temperature elevated for 5 days
W M	Perforated ulcer	Alpha hemolytic streptococci	1,000,000 units every 6 hr for 29 doses	Penicillin 15,000 units every 3 hr	Temperature elevated for 7 days
F G	Perforated ulcer	B subtilis 0.25 alpha hemolytic streptococci anaerobic diphtheroid, anaerobic gram positive coccus	1,000,000 units every 6 hr for 25 doses intramuscularly	Penicillin 20,000 units every 2 hr intramuscularly	Wound infection developed from which were recovered yeast resistant to more than 250 units per cc alpha streptococci, anaerobic diphtheroid, Staph albus resistant to 0.5 unit per cc, rash and drug fever abated on 9th postoperative day 3 days after drug discontinued
F Mc	Perforated ulcer	No growth	1,000,000 units every 6 hr intramuscularly for 13 doses	Penicillin 15,000 units intramuscularly every 3 hr	Temperature normal in 3 days
P T	Perforated ulcer	No culture	500,000 units every 6 hr intramuscularly for 17 doses		Temperature normal after 5 days
B K	Perforated carcinoma of the cecum	Staph aureus, alpha hemolytic streptococci, Esch coli, anaerobic diphtheroid anaerobic gram positive rod with spores, not identified	1,000,000 units intraperitoneally at operation 1,000,000 units every 12 hr intramuscularly for 26 doses		No benefit, wound infection developed death

mycin therapy, 1,000,000 S units in the abdomen at operation and 1,000,000 intramuscularly every twelve hours for twenty-six doses, the patient failed to improve and the wound became infected. Culture of material from the wound yielded a hemolytic *Staphylococcus aureus*, an alpha hemolytic streptococcus, Esch coli, an anaerobic coccus and an unidentified anaerobic gram-positive sporulating rod. The staphylococcus was sensitive to 8 units of streptomycin per cubic centimeter and the colon bacillus to 8 units also. Although this patient was perhaps not suitable for treatment, it is in such circumstances that help is needed.

It has been shown that streptomycin can be recovered from peritoneal exudate after systemic administration.⁵ If the organisms causing peritonitis are susceptible to streptomycin, such treatment should be beneficial. Apparently the reason that treatment with streptomycin was not attended by spectacular success is that peritonitis is usually a mixed infection and a number of the bacteria involved are resistant to streptomycin. Among the most important of the resistant organisms are the non-spore-forming anaerobes.

Infections of Soft Tissues—In this group there were 3 patients with pelvic abscess due to salpingitis or perforation of the bowel and 3 patients with wounds of the back or buttocks, in 1 of whom the wound followed injection of liver extract into the gluteal muscles, in 1 it was a shotgun wound of the back and in 1 a large undermined area of the lower part of the back and buttocks, which had started as a decubitus ulcer. There were, in addition, 6 patients with the following infections: hepatic abscess secondary to pelvic inflammatory disease, infected nephrectomy wound of flank, infected wound of the abdominal wall following ileo-transverse colostomy, abscess of the breast, abscess of subcutaneous tissue of the thigh and cellulitis of subcutaneous tissue of the thigh. In only 1 of the cases can it be established that streptomycin played an important role in curing the infection. Failure in the other cases can be attributed to the presence of anaerobic non-spore-forming organisms, resistant aerobes or an inadequate dose of streptomycin.

The following case illustrates the type of response that occurred in this group.

M. W., a 39 year old Negro woman, had an exploratory laparotomy on March 24, 1945 and was found to have diffuse peritonitis due to pelvic inflammatory disease. The wound was closed without drainage. On April 1, 1945 an abscess presented in the lower aspect of the wound and was drained. A large quantity of foul yellow pus continued to escape from the abscess, which extended into the pelvis. Alpha and beta hemolytic streptococci, *Bacteroides melanogenicus*,

5 Buggs, C. W., Pilling, M. A., Bronstein, B., and Hirshfeld, J. W. The Absorption, Distribution and Excretion of Streptomycin in Man, *J. Clin. Investigation* 25:94-102, 1946.

an anaerobic gram-positive coccus and anaerobic diphtheroids were recovered from the pus. Streptomycin therapy was started on April 4, the patient receiving 500,000 S units intramuscularly every six hours and 500,000 units in 1,000 cc of isotonic solution of sodium chloride dripped constantly in the wound during twenty-four hours. On April 7 the intramuscular dose was increased to 1,000,000 S units every six hours. On April 11 the drip in the wound was discontinued, and by April 13 the intramuscular therapy was stopped because of severe toxic symptoms in the form of fever, generalized myalgia and painful swelling of the shoulder and wrist joints. Six hours after the last intramuscular dose of streptomycin, the serum concentration was 173 S units per cubic centimeter. Although the wound had improved a great deal, several observers agreed that the improvement was no more than would have occurred without chemotherapy. The alpha and beta hemolytic streptococci had been eliminated, but the anaerobes remained unchanged. In addition, *Staph aureus* and an aerobic diphtheroid had appeared. The wound finally closed, and the patient was discharged, only to return three weeks later with a recurrent abscess.

The experience with this group of cases indicates that streptomycin is not effective against *Bacteroides melaninogenicus* and many of the anaerobic cocci which play such a prominent part in infections originating from the intestine or female genital organs. Unfortunately, many of the soft tissue infections which harbor gram-negative organisms such as *Esch coli*, which are susceptible to streptomycin, also contain these resistant anaerobes. Until an antibiotic is found which will at least inhibit these organisms, the use of streptomycin will produce only partial improvement. If some means is found to control the organisms that are resistant to streptomycin, the use of a combination of the two agents should be extremely effective.

Infections of the Urinary Tract—Streptomycin was given to 13 patients with infections of the urinary tract. In 7 of these patients therapy eliminated the infecting organisms from the urine, while in 6 the urine was not sterilized. In 5 of the 6 cases with unsatisfactory outcomes failure was due to the presence of organisms which were resistant at the time therapy was instituted, while in 1 case the organisms appeared to be extremely susceptible when therapy was started but, for some reason, acquired resistance rapidly and were not eliminated. After parenteral administration a large proportion of the streptomycin is excreted in the urine,⁵ and it is logical to expect that streptomycin will be effective in the treatment of urinary infections provided the organisms are susceptible. Many of these infections are mixed, and, since some of the organisms are apt to be resistant, streptomycin often will have to be used in combination with other agents in order to insure success.

Infections of Bone—There were only 2 patients in this group.

One was a 38 year old Negro woman in whom painful swelling of the right thigh developed four months before she was admitted to the hospital. This had occurred shortly after a confinement. On admission to the hospital, April 17, 1945,

she was found to have an extensive soft tissue abscess of the right thigh, which apparently had its source in the femur. The abscess was drained, and culture of the pus yielded a beta hemolytic streptococcus and an anaerobic coccus. For a time the patient improved, but after a short time she became febrile again and on May 4 streptomycin was started, 1,000,000 S units intramuscularly every six hours. Streptomycin had to be discontinued after twenty-one doses because of nausea and vomiting and pain at the sites of injection. Penicillin therapy was substituted. Two days later a new lot of streptomycin was obtained, and the drug was started again in doses of 1,000,000 S units every six hours. At this time, culture of material from the wound yielded *Staph aureus*, diphtheroids, *Pseudomonas aeruginosa*, an alpha hemolytic streptococcus and an anaerobic coccus, all the aerobes were resistant to more than 256 units of streptomycin per cubic centimeter of culture medium. The resistance of the anaerobes to streptomycin was not determined. The drug was discontinued after four days because of the severe local irritation at the sites of injections, the resistance of the aerobes and the failure of the anaerobes to disappear. Although this patient received only a short course of treatment, streptomycin seemed to have no effect. The anaerobes persisted, and the wound became contaminated with resistant aerobes during therapy.

The other patient was a man of 70 years, who had a chronic ulcer over the internal malleolus of the left ankle which finally involved the joint. While the organisms recovered from the wound varied somewhat from time to time, *Ps aeruginosa*, *Bacteroides melaninogenicus* and a gram-positive anaerobic coccus seemed to be constantly present. These organisms persisted throughout eighteen days of treatment, during which time the patient received 500,000 S units of streptomycin intramuscularly every six hours and 1,000,000 S units in 1,000 cc of isotonic solution of sodium chloride locally over each twenty-four hour period.

Failure in these 2 cases does not indicate that streptomycin will be of no value in osteomyelitis caused by susceptible organisms. It does indicate, however, that it will probably fail when *Bacteroides melaninogenicus* and other anaerobic bacteria are present. Furthermore, it indicates that during treatment open wounds may become contaminated with other bacteria which either are resistant or acquire resistance rapidly.

Granulating Surfaces—Four patients were studied who had sloughing or granulating wounds resulting from third degree burns or avulsion of skin. The drug was applied locally as a wet dressing in concentrations of 200 to 500 S units per cubic centimeter. All the patients did well in that the granulating areas became red and healthy and grafts took well. Interestingly, there was no significant change in the bacterial flora, most of the organisms which were present at the start of therapy still being present when it was discontinued. During the period of therapy, their resistance to streptomycin increased remarkably. It is difficult to evaluate this small group of patients. They might have done just as well with moist dressings of isotonic solution of sodium chloride.

Diabetic Gangrene—In this group of 4 patients, there were 2 for whom streptomycin therapy was classed as failure. In 1 case, that of

a patient with an infected amputation stump and renal failure, streptomycin was started only a few days before death and obviously did not have a fair trial. The other failure occurred in a patient with an infected foot. Streptomycin was employed both as a local drip of 1,000 S units per cubic centimeter and as an intramuscular injection in doses of 500,000 S units every six hours. The infecting organisms were as follows:

	In Vitro Resistance to Streptomycin, Units per Cc
<i>Ps. aeruginosa</i>	128
Gram negative rod (unidentified)	96
<i>A. aerogenes</i>	56
Alpha hemolytic streptococci	80
Anaerobic gram positive coccus	Not done

The serum level was 36 S units per cubic centimeter six hours after a dose on the second day of therapy. During four days of treatment, the foot became worse, so that amputation was finally done. Culture at this time yielded:

	In Vitro Resistance to Streptomycin, Units per Cc
<i>Ps. aeruginosa</i>	256
Unidentified gram negative rod	80
Alpha hemolytic streptococcus	56

The other 2 patients showed remarkable improvement of their infection under local streptomycin treatment. In 1 case, that of an infected amputation stump, the concentration of streptomycin employed locally was 200 S units per cubic centimeter, while in the other, a case of an infected foot, it was 2,000 S units per cubic centimeter.

It was not possible to correlate the bacteriologic observations with the clinical improvement.

Miscellaneous—A number of patients were treated whose infections could not be classified in any of the preceding groups. Their diseases are as follows:

	No. of Patients
Miliary tuberculosis	1
Tuberculous meningitis	1
Acute pulmonary monilliasis	1
Chronic prostatitis	1
Urethral fistula	1
Friedländer's pneumonia	1
Chronic cholangitis	1

S. B., the patient with miliary tuberculosis, was admitted to the hospital on May 11, with no symptoms other than temperatures as high as 104 F, for three weeks prior to admission. Physical examination was entirely noncontributory, but roentgenologic examination revealed a fine mottling of both pulmonary fields suggestive of miliary tuberculosis. The temperature ranged from 100 to 104 F. By May 28 fine rales had appeared in both pulmonary fields. Administration of

streptomycin was started on May 25 in doses of 1,000,000 S units intramuscularly every six hours and was continued for one hundred and twelve doses. Serum levels were as follows

	Hours After dose	Units
After 1,000,000 S units	2	26.5
	4	15.2
After 16,000,000 S units	2	31.0
	4	19.0
	6	16.8
After 48,000,000 S units	2	26.4
	5	13.6
After 77,000,000 S units	2	26.7
After 78,000,000 S units	1	32.7

During treatment there were no perceptible changes in the patient's course. Some time after treatment was stopped he died, and the diagnosis of miliary tuberculosis was established at autopsy.

The patient with tuberculous meningitis was a boy 4 years old, who was almost moribund when streptomycin therapy was initiated. He received 750,000 S units intramuscularly every six hours for a total of eight doses. He also received 10,000 S units intrathecally. Six hours after the first dose the serum concentration was 31.8 units per cubic centimeter, six hours after the third dose it was 17.1 units, and at the time of death, five and one-fourth hours after the last dose, it was over 300 units.

Streptomycin obviously did not have a fair trial in this case. Whether the high concentration of streptomycin contributed to his death is not known. The case does illustrate that streptomycin may accumulate in a critically ill patient and emphasizes the need for caution in the treatment of such patients.

The case of acute pulmonary moniliasis deserves little comment. The organism was completely resistant to streptomycin, its *in vitro* sensitivity being greater than 250 units per cubic centimeter. Treatment had no perceptible effect on the course of the disease.

No benefit was obtained in the case of chronic prostatitis. Although there was considerable variation in the bacteria which were recovered, probably due to contamination from the urethra, an alpha hemolytic streptococcus with a sensitivity of 4 to 16 units per cubic centimeter appeared to be the causative organism. Treatment consisted in administration of 500,000 S units intramuscularly every six hours. After twenty-five doses, drug fever developed and therapy had to be discontinued. Unfortunately, no serum levels were obtained, and it is possible that failure was due to an inadequate dose.

The patient with a urethral fistula had had a suprapubic cystotomy in 1931, for an unknown reason. He had remained well until October 1944, when a purulent urethral discharge developed. The cystotomy wound opened, and a perineal abscess formed. After the abscess was drained, a urethral fistula appeared.

The fistula failed to heal, the wounds were indolent and the urine was thick and foul. Culture of materials from the bladder yielded the following organisms

	Resistance to Streptomycin, Units per Cc
<i>Staph aureus</i>	0.45
Beta hemolytic streptococcus	1.90
<i>P. vulgaris</i>	0.45
<i>P. aeruginosa</i>	14.30
<i>Bacteroides melaninogenicus</i>	Not done
Anaerobic diphtheroid	Not done
Anaerobic gram negative bacillus	Not done

Treatment with streptomycin consisted in emptying the bladder, then in instilling 100 cc of a solution containing 200 S units of streptomycin per cubic centimeter into the bladder every four to six hours. The patient retained the material for several hours by plugging the cystostomy opening, after which he voided. Four days of therapy was sufficient to cause pronounced improvement, cultures at this time yielded *Proteus vulgaris*, *Staph aureus*, a diphtheroid and anaerobes which could not be isolated. Improvement continued, and both wounds healed promptly.

The case of chronic cholangitis deserves little comment, since the dose was too small to be effective. This patient was one of the first to be treated and he received only 10,000 S units every two hours and then, after a few days, 50,000 S units every two hours. There was no effect on his course or on the bacterial flora of the drainage from the common bile duct. The organisms were sensitive to small concentrations of streptomycin, and failure is probably explained by the inadequate dose.

Although streptomycin failed in the patient with Friedländer's pneumonia, this case cannot be accepted as indicating in any way the place of streptomycin in the treatment of this condition. The patient, who was 58 years old, was admitted to the hospital primarily because of a cerebral vascular accident. During examination it was discovered that he had extensive pneumonia. Although *Klebsiella pneumoniae* was the predominant organism in the sputum, many other organisms were present in the sputum.

	Sensitivity to Streptomycin Units per Cc
<i>K. pneumoniae</i>	0.25
Alpha hemolytic streptococci	Not done
<i>Staph aureus</i>	2
<i>M. aurantiflavus</i>	1
Gram negative bacilli	4
<i>M. candidus</i>	1
<i>Esch. coli</i>	5
<i>Bacteroides melaninogenicus</i>	Not done
Anaerobic gram negative bacilli	Not done
Anaerobic diphtheroid	Not done
Anaerobic gram positive coccus	Not done

The patient received 1,000,000 S units intramuscularly every six hours. Serum levels following the first dose were 10.1 units per cubic centimeter at two hours, 11 at four hours and 7.3 at six hours. He died after receiving 7,000,000 S units.

Streptomycin was used prophylactically in an attempt to prevent peritonitis in 2 patients in whom the peritoneum was soiled during operative procedures. In 1 case, that of a patient with ulcerative colitis in whom the colon was torn, no infection occurred. In the other case, that of a patient with intestinal obstruction in whom the bowel was torn and extensive soiling occurred infection did occur, but she recovered, the convalescence being far smoother than was anticipated. It is difficult to say how much benefit was obtained from therapy in these cases, but certainly the results indicate the need for further trial.

TOXIC SYMPTOMS

Streptomycin was administered to 56 patients the cases of 4 not being included in this paper because of insufficient data. The discrepancy between the number of cases reported in the paper (55) and the figures just given is due to the inclusion of 3 patients under two categories. Of the 56 patients who received streptomycin, 12 exhibited definite toxic symptoms and 1 manifested symptoms which may have been due to streptomycin.

The toxic symptoms were fever, rash, weakness, myalgia, arthralgia, arthritis, nausea and vomiting. The 1 fatal case, in which symptoms may have been due to streptomycin (A. G.), was discussed in the bacteremia group. The toxic symptoms were usually severe enough to warrant cessation of therapy. Whether they were due to impurities which can be eliminated as the process of manufacture is improved or to streptomycin per se is not known. In addition to these toxic symptoms, most patients complained of considerable pain and persistent soreness at the sites of intramuscular injections. In many instances these areas exhibited induration, which persisted for several days.

COMMENT

The patients whose cases are presented in this paper were selected for treatment in order to test the value of streptomycin. Some patients were chosen because they had lesions which were probably hopeless, while others were treated because they had infections which, while not customarily fatal lesions, were those for which there was no satisfactory treatment. Still others were included in hopes that streptomycin might prove to be better than the current treatment. It is for these reasons that the cases are so varied. Although neither the total experience nor the number of cases in any one group is large, we believe that it is possible to draw certain conclusions from this experience.

First, it is fairly clear that streptomycin is capable of sterilizing the blood stream in short order provided the infecting organisms are susceptible to a serum concentration of the drug that can safely be maintained. If a larger experience proves this statement to be true, it

means that streptomycin will be a valuable agent in the rare cases of septicemia due to *Esch coli*, *A aerogenes*, *Ps aeruginosa* and other gram-negative bacilli

Second, streptomycin, since it is excreted in high concentrations in the urine, is able to sterilize urine that is infected with susceptible organisms. Used in conjunction with other agents, streptomycin should make it possible to cure more patients with mixed infections of the urinary tract than it has been possible to do in the past.

The apparent lack of response to therapy of the patients with peritonitis and infections of the soft tissues was disappointing. This is probably due to the fact that in most instances these were mixed infections, in which some of the organisms were resistant. The nonsporulating anaerobes seemed to be the chief offenders in this regard. In spite of the failure of streptomycin to render these lesions sterile, its use is still rational for the elimination of some of the organisms and should make it easier for the body to combat those which remain.

Streptomycin seems to follow the rules that hold for the sulfonamide drugs and penicillin in that it does not sterilize walled-off collections of pus or wounds harboring dead tissue and foreign bodies. Its use in such instances is not wise, because many bacteria seem to acquire resistance to streptomycin rapidly. It is wiser, therefore, by adequate surgical treatment to render the conditions as suitable for its action as possible before streptomycin therapy is initiated.

Streptomycin therapy at present is accompanied with a high incidence of toxic symptoms. Whether these can be reduced as the process of manufacture is improved is not known.

SUMMARY

Fifty-six patients with various types of infection were treated with streptomycin. Manifestation of toxicity occurred in 12 of these patients.

In patients with bacteremia or septicemia, streptomycin sterilizes the blood stream promptly provided the organisms are susceptible to its action.

Streptomycin does not sterilize walled-off collections of pus, even though the organisms involved are susceptible to its action.

Owing to the high concentration in which streptomycin is excreted in the urine, it is a valuable agent for the treatment of infections of the urinary tract, provided the organisms are susceptible to its action.

The results of treatment of patients with peritonitis and various types of infections of the soft tissues were disappointing. Most of these infections were caused by a mixture of several kinds of bacteria, and failure in the majority of instances can be attributed to the presence of resistant organisms, the most prominent group of resistant organisms appeared to be the nonsporulating anaerobes.

PHYSIOLOGIC CONSIDERATIONS IN THE CARE OF PATIENTS WITH VARICOSE VEINS

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THE current shortage of labor has increased the number of patients who seek treatment for varicose veins or their complications. The symptoms, which previously had been negligible or at least tolerable, have become important after long hours of work. If these patients are to be able to work in comfort, they must have more treatment than the casual bandage, injection or ligation. So it seems worth while to present, somewhat dogmatically, a system of management which applies to the large majority of the simpler cases. It lays no claim to newness or fundamental originality but is founded on the practices developed at the Outpatient Department of the University of California Medical School. This treatment of ulcers has been tested in the Outpatient Department of the John Sealy Hospital at Galveston, Tex.

PHYSIOLOGY AND PATHOLOGY

The chief features of all varicose conditions, considered from a physiologic point of view, are valvular incompetence, raised venous pressure and edema.

Probably the commonest primary defect is congenital inadequacy in one or more pairs of venous valves at the upper end of the long saphenous system. The transmission to the saphenous system of a pressure wave, on coughing or straining, shows that the valves in the femoral vein just above the saphenous opening are commonly faulty (Adams¹). Occasionally (1 per cent of all cases of Ochsner and Mahorner²) a valve may be at fault where the lesser saphenous vein pierces the fascia to join the popliteal vein. The familial tendency³ of these disorders strongly

1 Adams, J. C. Etiological Factors in Varicose Veins of the Lower Extremities, Surg, Gynec. & Obst. **69** 717 (Dec.) 1939

2 Ochsner, A., and Mahorner, H. Varicose Veins, St. Louis, C. V. Mosby Company, 1939

3 de Takats, G., and Quint, H. The Injection Treatment of Varicose Veins, Surg, Gynec. & Obst. **50** 545 (March) 1930

suggests congenital weakness. But in some patients, varicose veins must be ascribed to destruction of valves during thrombophlebitis, superficial or deep, of the leg and thigh. Because damage is widespread, such patients are difficult to treat satisfactorily.

With regard to the common and probably congenital type, it seems likely that mild incompetence during the years prior to adolescence may alter the function thereafter. Generalized venous breakdown may be accelerated or precipitated by pelvic congestion (uterine enlargement at puberty or pregnancy, constipation, pelvic inflammatory disease, fibroids or other conditions), by prolonged standing or by occupations which involve repeated straining, with raised intra-abdominal tension.

As the upper valves fail, the column of blood sustained by the lower valves becomes longer and therefore heavier, and they, in turn, give way. The increased tension within the larger veins usually produces a thickening of their muscular coat so that they feel straight, firm and thick. Such vessels extirpated from young subjects have been reported as arteries after casual pathologic examination. Prolonged increase of pressure on the smaller vessels tends to produce distention, thinning and tortuosity of the veins—the typical varix.⁴

In such veins the course of the blood is demonstrably downward, toward the lower part of the calf. Here the blood enters the deep veins by the vessels perforating the fascia and ascends, only to flow back via the saphenofemoral junction or a perforating vessel in the thigh whose directing valve is incompetent. Thus, reverse flow is established, with raised venous pressure and venous stagnation.

The stagnant anoxia and raised venous pressure combine to upset the balance of turnover of the tissue fluid and produce edema. The chronic stretching of the connective tissue by excess tissue fluid or the chronic anoxia from stagnation of the tissue fluid or perhaps both are followed by formation of fibrous tissue and discoloration of the skin.

I VARICOSE VEINS WITHOUT COMPLICATIONS

History—The familial incidence of varicose veins, the amount of disability they have caused and the effects of treatment should be investigated. The rate of development of signs and symptoms, the responses to treatment and occupational changes, the effects of pregnancy or abdominal diseases and the probable expectation of life of the patient, obtained from an examination of personal, family and occupational history, should be used to evaluate the prognosis of the varicose condition and the probability of recurrence after treatment. Often it will be found that the treatment of choice and the advice given with respect to occupa-

⁴ Epstein, S. Ueber die Structur normaler und ectatischer Venen, Virchows Arch f path Anat 108 239, 1887.

tion may be determined by the fact that a particular patient has a short expectation of life and his varices have a tendency to progress only slowly, in contrast with the patient who has a long expectation of life and whose varices have a tendency to progress rapidly. Evidence should be sought which might indicate extra caution in the use of intravenous treatments and also the psychologic and the physical factors which might determine the advisability of surgical procedure. Inquiry should be made as to itching, tenderness, aching, heaviness, swelling or tiredness, particularly in the calves and ankles. Examination and history should be weighed to evaluate the adequacy of the arterial circulation below the knee, since arterial inadequacy makes treatment by injection or operation more hazardous. Particular attention should be paid to the exact time, nature, quality and success of previous treatments and to a history which might be interpreted as thrombophlebitis. In this connection, if the condition of the patient required his being hospitalized or confined absolutely to bed for a period of ten days or longer, the thrombophlebitis was almost certainly in the deep femoral system. The history of superficial saphenous thrombophlebitis shows variation and confusion.

Examination—The size and apparent tension of all visible veins in the lower extremity should be noted and a search made for varices in the vulva, the lower part of the abdomen and the gluteus muscles. Whether visible or not, the long saphenous vein should be palpated and traced throughout its course by the transmission of a percussion wave along it (Schwartz test). When it is stroked empty and allowed to fill from above, convincing evidence should be obtained that the saphenous vein is conveying blood downward (reverse flow). The procedure should be applied also to as many branches as possible. The thickness of its wall should be noted. The arterial circulation should be evaluated by the temperature of the feet, their color when dependent, the qualities of the skin, the palpation of the posterior tibial and dorsalis pedis arteries and such other tests as may seem helpful. At the same time the feet should be examined for deformities or orthostatic defects which might be producing pain or tiredness.

It is seldom that treatment of the veins will affect complaints above the knee. Any pain or discomfort above the knee should instigate a diligent search for causes other than varicose veins. Usually the exceptions are small superficial veins on the outer thigh or the vulva. The results of treatment of vulval varices during the child-bearing years are unsatisfactory (Homans⁵), but injections early in pregnancy often give temporary relief and have not been found to complicate delivery. A

⁵ Homans, J. *Circulatory Diseases of the Extremities*, New York, The Macmillan Company, 1939.

further, but obvious, exception is the pain arising from superficial saphenous thrombophlebitis. The exquisite pain of this condition usually is promptly relieved by ligation high in the saphenous system. The presence of ulceration, dermatitis, edema, pronounced telangiectasia or pigmentation should be noted at this time, their bearing on treatment will be discussed later. Careful examination should be made for cracks between the toes, macerated thickened white skin, abnormal proliferation of epithelium around the legs and other evidences of fungus diseases.

Tourniquet Tests—While the patient lies on his back, his foot is elevated and a narrow rubber tourniquet applied tightly just below the head of the fibula, then he is brought immediately to his feet. Normal filling of the veins below this tourniquet by blood flowing through the capillaries will take from twenty-five seconds to a minute or longer. It is more rapid in the lower part of the leg and depends largely on the temperature of the feet. By contrast, in the absence of any unusual condition, such as an arteriovenous aneurysm, filling of these veins in less than twenty-five seconds is from above and indicates either that the tourniquet is not sufficiently tight or else that the perforating veins, which normally carry blood from the superficial external and internal saphenous systems to the deeper veins of the leg, are carrying their blood in the reverse direction as a result of valvular incompetence. It is of great importance that the status of these valves be evaluated surely, because the patient with incompetent communicating valves below the knee can at best be rehabilitated only partially, he must be taught to exercise constant care and to expect more or less trouble during the rest of his life.

Whether the perforated veins below the knee are competent or not, the same tourniquet test is repeated with the tourniquet a little above the knee. Here again, tightness of the tourniquet is of great importance. If the hamstring tendons are such that there is doubt as to whether the veins are properly occluded, a pad of cotton placed under the tourniquet over the saphenous vein will assure the occlusion. As the patient stands, rapid filling of the vein indicates reversed flow in a vein perforating the fascia distal to the tourniquet, if there has been no incompetence below the knee, it may be inferred that one is dealing with incompetence at the place where the short saphenous vein perforates the fascia into the popliteal space.

A tight tourniquet should next be placed high up on the thigh, below the saphenofemoral opening, and the test repeated. Rapid filling in this case suggests a major incompetence somewhere in the length of the thigh, and this has been shown to occur most commonly about 16 cm above the knee. Finally, while the patient is standing the tourniquet at the top of the thigh is released, and rapid or immediate filling indicates

incompetence of the valves of the long saphenofemoral opening. The large majority of all patients with varices or symptoms due to venous back pressure have gross incompetence at the saphenofemoral valve, of these, a large proportion reveal some degree of incompetence in the thigh, although this often is difficult to evaluate.

In the evaluation and localization of incompetent valves in perforating vessels in the thigh, the comparative tourniquet test of Mahorner and Ochsner⁶ is often valuable and should be studied.

Treatment—The aim of all treatments of varicose veins is the elimination of back pressure on the capillaries, which gives rise to all the symptoms and disabilities, and since this back pressure originates from the fact that there is somewhere, usually at the saphenofemoral opening, an incompetently guarded communication between superficial and deep systems of the veins so that blood tends to flow backward and down the superficial veins, the logical treatment is the elimination of all the perforating vessels whose valves are incompetent. The only way in which one can be sure of achieving this is to ligate each of the affected perforating veins and excise part of the vein at the time. This procedure is relatively straightforward in the case of perforation at the saphenofemoral opening and it is spoken of as "high saphenous ligation." It may be performed with the patient under local infiltration anesthesia, but the operation should not be regarded as an office procedure (see recent discussion by Atlas⁷) unless it is performed by a surgeon with considerable experience in an office unusually well staffed and equipped. Inquiry tends to show that the more experience a surgeon acquires, the less he is inclined to regard this as an office procedure.

High saphenous ligation has been adequately described many times,⁸ but it is still necessary to emphasize, first, that the dangers and the sources of error be kept in mind, and, second, that the operation will not give uniformly good results unless enough of the femoral vein is thoroughly exposed to make sure that no tributaries are formed above the point at which the saphenous vein has been tied. Any such tributary should be tied and cut and a sufficient length removed. The stump of the long saphenous vein should be tied as closely as possible to the femoral vein and a transfixed suture placed immediately distal to the tie. Two inches (5 cm) of the saphenous vein and any branches which may arise within these 2 inches should be excised, the vein and

6 Mahorner, H. R., and Ochsner, A. A New Test for Evaluating Circulation in the Venous System of the Lower Extremity Affected by Varicosities, *Arch Surg* **33** 479 (Sept) 1936.

7 Atlas, L. N. Hazards Connected with the Treatment of Varicose Veins, *Surg, Gynec & Obst.* **77** 136 (Aug) 1943.

8 Tavel. Behandlung der Varicen durch die Ligatur und die künstliche Thrombose, *Cor-Bl f Schweiz Aerzte* **34** 617, 1904.

branches having been ligated distally before excision. At this stage, most operators inject distally into the main trunk of the saphenous vein a sclerosing solution. The wisdom of this procedure has been questioned by Atlas⁷ and will be discussed later.

This operation should be followed by active movements of the legs to the fullest extent that they can be tolerated and the patient sent back to work within a few days. The amount of temporary disability from this operation is determined largely by the extent of reaction to the injection of sclerosing solution.

A large proportion⁹ of patients so treated return some months or years later with recurrence of the varicose veins. Many times these recurrent lesions are due to technical imperfections in the operation, such as ligation too low or failure to visualize the femoral vein and therefore failure to ligate all its branches at the upper end. In such cases, anastomotic channels may be established around the site of ligation and carry blood into varicose veins. Yet a considerable proportion of the recurrences are in patients in whom the original surgical operation appears to have been technically satisfactory and in whom symptoms return without evidence of recurrence of incompetence in the region of the groin. On repetition of the test outlined, it is shown that the recurrence is due to a back flow from the femoral vein through the perforating vessels in the thigh into the saphenous system and recanalization of the saphenous system. The logical procedure here would be to locate and tie the perforating vessel in the thigh. This is often not one vessel but several, their locations are difficult to determine, and, in fact, systematic anatomic description of this part of the saphenous system and its connections rests entirely on the recent work of Sherman⁹, it is reasonable to suppose that further work in confirming Sherman's findings will give additional information as to the constancy and the inconstancy of the location of these vessels. In view of the difficulty of locating these particular vessels, Sherman has advocated and used with great success a revival of the Mayo stripping procedure.

Sherman's procedure is designed to interrupt the perforating vessels which communicate between the deep (femoral) and the saphenous system of the veins, the removal of the long saphenous vein is incidental to this end. Because of the common recurrence after simple high ligation, Sherman advised that the stripping operation be done at the same time as the high ligation whenever there is evidence of incompetent midthigh perforators. Stripping might sometimes be done for prophylactic reasons, even when this evidence is not obtainable. Hemorrhage, which might be expected to accompany this operation, is controlled by injection of a sclerosing solution. Three to 5 cc of solution of monoethanol-

9 Sherman, R. S. Varicose Veins. Anatomic Findings and an Operative Procedure Based upon Them, *Ann Surg* **120** 772 (Nov) 1944

amine oleate is injected into the distal stump of the great saphenous vein during the operation, and the vein is then nicked and inspected to make sure that it does not bleed. The procedure is designed to explore the pattern taken by the saphenous vein and to avulse all parts of it which might communicate with the deep system. The technical details are adequately described in the original article. Local infiltration anesthesia is not satisfactory, spinal or general anesthesia are preferable.

Reaction to the trauma of passing the vein stripper down the length of the thigh and part of the leg is surprisingly small, and, in fact, these patients usually complain less of soreness than those who have had a simple high ligation with retrograde injection. It may be that removal of the vein and the sclerosing solution that it contains prevents the persistent inflammation which results otherwise. These patients usually are encouraged to use their legs as much as possible, they are sent home on the day following the operation and are back at work in ten days or so. This early return to activity is advisable so as to minimize the possibility of thrombosis with embolism and to promote rapid healing. It is important also since these patients are more cooperative if they are assured that they will be able to return to work almost immediately.

The immediate results of this procedure are extremely satisfactory to the patient and appear to achieve what is desired, as far as can be measured by available methods for testing. The logic of this method leads one to suppose that the results may be permanent in the large majority of patients (that is to say, patients in whom there is no incompetence of the short saphenous vein or of the veins below the knee), but, naturally, a further report on Sherman's early cases must be awaited before this treatment can be offered as a permanent cure.

Many authors, feeling that a stripping operation is too radical a procedure for most cases, advocate a simultaneous high and low ligation of the internal saphenous vein. In many patients so treated, severe varices and their complications continue to develop.

So far, no mention has been made of treatment by injection. Injection of sclerosing solution often will give complete relief of symptoms but usually is followed by recanalization and recurrence, sometimes within twelve months and usually within three years, although occasionally one meets patients who have been treated satisfactorily by injection seven or eight years prior to the recurrence. Because of its temporary nature, it seems that the sclerosing treatment is useful only in certain limited ways. These may be listed as follows: (1) as a treatment of trifling varices for cosmetic reasons, (2) as a procedure in cases in which arterial insufficiency, short expectation of life or other general reasons contraindicate surgical intervention, (3) as a temporary measure when it is necessary to defer operation, (4) as a treatment when surgical operation is refused, (5) as a procedure during pregnancy, (6) as a

supplement to surgical treatment, both before the stripping operation and afterward, to obliterate any distended veins which do not disappear after operation, and (7) as a measure in cases in which incompetent perforating veins below the knee limit the success of operative procedure. The short saphenous perforator, when incompetent, may be satisfactorily ligated when necessary where it perforates the fascia. Many varices of the short saphenous system are referable to its connections with the long saphenous system.

Incompetent perforating veins below the knee cannot as a rule be satisfactorily ligated, because they usually are multiple and of uncertain location. The prognosis of the patient with this condition is poor, and he must be educated to remain constantly on guard. His long saphenous vein should be ligated or stripped if there is clear evidence that it is involved. Into every accessible vein in his calf injections should be made carefully, and he should frequently be examined for veins which require injection. Whenever edema is detected, it should be eliminated either by rest in bed or by a tight pressure tape. When edema has been eliminated, its return should be prevented either by a tight heavyweight elastic stocking or by a heavy, well fitted canvas gaiter. Extreme care must be taken to prevent trauma and fungus infections, as these are the principal precipitating causes of varicose ulcers, particularly with incompetent valves in the perforating veins below the knee.

II COMPLICATIONS OF VARICOSE VEINS

The outstanding complications of varicose veins are (1) dermatitis or eczema, (2) edema, (3) varicose ulcer and (4) thrombophlebitis.

Dermatitis—Itching is a common symptom among patients with varicose veins. The complaint varies from mild occasional itching to severe weeping dermatitis complicated by scratching, or a dry, exfoliative type of dermatitis with considerable fibrosis of skin and subcutaneous tissues. The itching may be due in part to the rapid migration of fluid from one part of the tissue to another, particularly in the skin where there are nerve endings which characteristically give rise to this sensation. This may be compared with the itching along the advancing edge of the lesion of giant urticaria, but it is probable that the greater part of the itching in patients with varicose veins is associated with fungus infection. The fungus tends to thrive on the moist surface of edematous tissue, the low oxygen tension which probably obtains as a joint result of the reflux of blood and the stagnation of tissue fluid also favors fungus infection. Attempts to establish the role of the fungus in varicose dermatitis are not yet conclusive, however, careful control of fungus infection often leads to the rapid cessation of itching and the regression of the physical signs of the dermatitis, whereas when a localized fungus infec-

tion is permitted to spread intolerable itching occurs. The cutaneous lesions often become secondarily infected with pyogenic organisms. For these reasons, the prime treatment of varicose dermatitis consists in control of the edema which allows the fungus to thrive. Measures directed toward the destruction of the fungus itself are helpful, considerable study has been given to the relationship between fungus infection and various vascular disorders of the extremities by Thompson,¹⁰ whose work bears importantly on the topics discussed in this paper.

Moderate varicose dermatitis usually responds promptly to high ligation of the saphenous vein if there is no evidence of other venous incompetence, but, in view of the likelihood that the infection will invade the site of operation, it is probably wiser to defer surgical treatment until the dermatitis is controlled. The importance of postponing radical treatment was clearly apparent during the care of 2 patients with ulcers and severe obstinate lymphedema. Apparently this lymphedema had developed as the result of low grade infection in the groin. This infection occurred shortly after high saphenous ligation had been performed without previous control of obvious infection below the knee. The chain of cause and effect is not established by these cases, but they constitute a warning.

Occasionally, if the edema is not pronounced, varicose dermatitis will respond to the simple application of 5 or 10 per cent silver nitrate in 50 per cent alcohol to the entire surface involved and to the interdigital spaces and the crevices around the nails. Yet again, success may be had by the application of a tight inelastic support, of the nature to be described for the treatment of varicose edema, though in certain instances the warmth and the moisture which accumulate beneath such a dressing, by encouraging the multiplication of fungi, produce more harm than the reduction of the edema warrants. In cases in which it is economically possible, a few days in bed with the legs elevated will reduce edema. The itching usually can be controlled and the weeping dried by the frequent application of a turkish towel wrung out of a hot strong solution of magnesium sulfate. The immediate relief of itching is essential for effective treatment. In a refractory case, the judicious use of dilute phenol preparations locally or barbiturates internally should be tried once or twice early in the treatment. In the cases of the most obstinate dermatitis, with considerable weeping and little edema or when the response to the treatment of edema does not clear up the dermatitis, mild roentgen therapy once a week for three weeks or so is helpful.

In any case, when the dermatitis has been alleviated the leg must be thoroughly supported until successful operative measures control the

¹⁰ Thompson, K. W. Studies on the Relationship of Dermatomycosis to Ulceration and Gangrene of the Extremities, *Yale J Biol & Med* 16 665 (July) 1944.

edema more permanently If the edema has been eliminated completely, the most satisfactory way to continue its control is by the use of an adequate elastic stocking or a carefully designed garter

Edema—In all patients with varicose veins, the control of edema is paramount Pitting edema of recent origin if due to varicose veins can be eliminated rapidly by rest in bed, with the feet elevated In like circumstances, tight bandaging will produce the same results with less economic loss but usually with more discomfort This procedure is based on the work of Nobl,¹¹ Pondroff,¹² and others Since the effective use of the tight bandage depends on the proper balance of a number of technical details, its application is here described

Application of Pressure Bandage—First, the leg, foot and nails should be scrupulously cleaned by scrubbing with soap and water and then washed in alcohol and ether The whole leg from knee to toe, including all cracks, crevices and surfaces of all lesions, should be painted with silver nitrate solution as a prophylactic measure against fungi To provide proper spreading, this salt should be in 50 per cent alcohol and be 5, 10 or 15 per cent silver nitrate The weaker solutions seem to be adequate if there is no recognizable evidence of active fungus infection The stronger solutions appear to be more effective in the control of fungus Silver nitrate produces irritation in a significant proportion of patients, the application should not be repeated in these, but attempts should be made to control the fungus by some other fungicide

Next, the leg should be given two coats of compound tincture of benzoin, time being allowed for drying between applications Care should be taken to prevent this solution from running in between the toes, because of its unpleasant stickiness

The same area is next carefully covered with a layer of cotton sheet wadding, every precaution being used to avoid wrinkles

Two pieces of $\frac{1}{2}$ inch (1.27 cm) rubber sponge are cut to fit the legs from end to end of the fibula, each being about 4 to 6 inches (10 to 15 cm) wide, according to the size of the leg The sponge rubber should be soft and all edges carefully beveled at a 45 to 30 degree angle These strips of rubber are placed outside the wadding on either side of the leg and temporarily held in place with $\frac{1}{2}$ inch adhesive tape If they are previously wrapped in cellophane, they may be used repeatedly

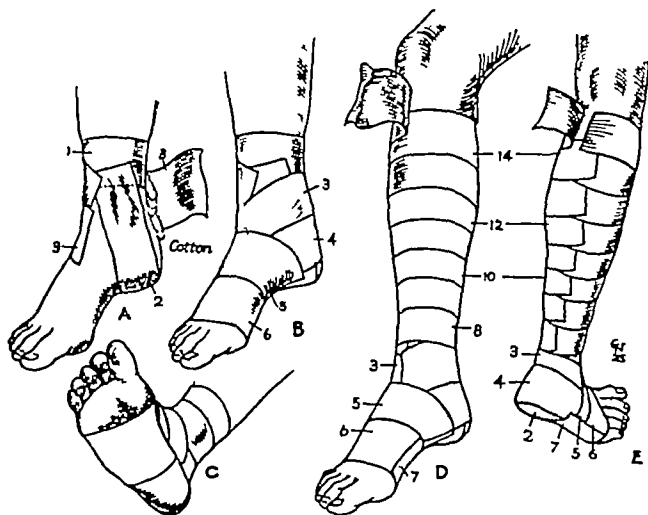
Next, a 4 inch gauze bandage is applied from the metatarsophalangeal joint over the sponges up to the knee, going around tightly up and down

11 Nobl, G Druckbehandlung von Stauungsgeschwüren, Wien. klin Wchnschr 37 644, 1924

12 Pondroff, cited by De Gaetano, L La cura ambulatoria delle ulcere varicose, Gazz. med lomb 84 99, 1925

the leg as often as may be necessary to insure that the sponges are well compressed, that all the cotton is covered and that there are no obvious kinks or pinches. Extra wadding should be placed over the tendo Achillis.

Adhesive tape should be applied in such a way as to encase the leg rigidly and to compress the rubber sponge to its maximum extent. Usually it is advisable to design the taping in such a way that at every place there are at least two thicknesses of tape. Although the types of compression and support desired cannot be achieved with the so-called elastic tapes, the water-proof type of tape is so inelastic that it invariably wrinkles and causes abrasions. For this reason, the old style, rough surface adhesive tape should be used.



Details of application of adhesive tape. Strips are applied in the numbered order as indicated in the text. If edema is evident, the tape should be applied as tightly as possible.

The following details (see figure) of application seem to have helped in preventing or minimizing the discomforts and abrasions which this procedure usually produces sooner or later.

1 A strip of 3 inch tape (7.6 cm) is applied as tightly as it can be stretched all the way around the leg just above the malleoli. The tightness of the whole taping procedure is of prime importance.

2 A stirrup of 3 inch tape is applied tightly, anchored to the first tape, passed over the internal malleolus and the plantar surface of the heel near the back and up over the external malleolus and anchored again to the first piece of tape.

3 One or two pieces of 3 inch tape are applied tightly, centered over the tendo Achillis overlapping each other passing over the malleoli and also over the back of the heel and extending down to ground level, with the ends crossing on the dorsal surface of the foot.

4 A tape is centered over the dorsal surface of the foot, passing transversely and finishing under the plantar surface. This tape is necessary to prevent bulging edema or to reduce edema of the dorsum of the foot, and for this reason it should be placed as low as is practicable. But, on the other hand, if it interferes in any way with the movement of the metatarsophalangeal joint it will produce bruising, discomfort and abrasions. For additional comfort, the sole, or rather the ends of tape which are under it, may be covered with a single piece of 3 or 4 inch (7.6 or 10 cm) adhesive tape.

5 Another piece of 3 inch adhesive tape is put directly over the first, and from there on a series of flat tapes is placed around the leg up to the top, with slight overlapping. Unless the bulge of the calf is exceptionally clear and prominent, it is important that the upper inch of tape be anchored directly to the benzoin-coated skin and not to the cotton. This prevents the dressing from slipping down the conical leg and failing to give support.

Before the dressing is considered complete, the tension of the sponge should be explored with the thumb in order that additional tight tapes may be applied wherever the sponge feels soft. This usually is necessary in the region of the ankle. It is particularly important to warn a patient when he is to wear this type of dressing that it involves some discomfort. Discomfort from the extreme degree of tightness with which it has been put on will wear off within an hour or so and will be negligible the following day, on the other hand, irritation, itching and discomfort may develop because the skin is covered and wrinkles may abrade it. Generally speaking, the patient will tolerate this first dressing for a week, but a clear understanding should be had that if the dressing is intolerable it must not be removed but that he will return to the physician for redressing. Flesh colored tape, which has proved perfectly satisfactory, is somewhat less unsightly than white. The liberal application of powder over the surface of the dressing half an hour after it is complete will prevent the adhesive from picking up fluff and other particles. If the patient is to wear such dressings for a long time, as is necessary with many patients with chronic ulcers or lymphedema, it is worth while to advise him that by rubbing the outside of the dressing with a block of paraffin he may render it sufficiently waterproof to enable him to take a quick shower.

Further Care—At the end of a week, the dressing may be removed by the physician. The leg should be cleaned with soap, alcohol and ether, abrasions should be touched up with silver nitrate or other coagulant antiseptics and protected with gauze or, better, with adhesive tape applied directly to the surface of the skin. The dressing should be put on again as before. The second and subsequent dressings usually can be worn for two weeks, depending on the resistance of the skin of the patient.

and on his temperament. The decision as to whether to repeat or to omit the application of silver nitrate every time or to change antiseptics must be an individual consideration. Thymol iodide seems to be helpful in some cases in which the skin is easily irritated. (Care must be taken not to use this compound with or immediately after a mercury antiseptic.)

In the application of pressure dressings care must be taken to be sure that there is adequate arterial supply. This involves not only the palpation of the dorsalis pedis and the posterior tibial arteries but also a general evaluation of the patient. In the case of a young person with normal arterial supply and considerable edema, the whole dressing should be applied with all the strength of which the ordinary physician is capable. In proportion as there is less edema, more gentleness should be used. The edges of the sponge if improperly beveled will give rise to blistering, in any case it is wise, on successive dressings, to move the sponges slightly in order to prevent repeated trauma.

When the edema has been eliminated by a few weeks of this pressure therapy, the leg of the patient should be measured carefully for a well fitting elastic stocking. This should be made of heaviest one way stretch lastex material available and so designed as to fit tightly at all points. A stocking with a seam down the back is significantly more satisfactory than a woven one. (Stockings with seams are at present unavailable because of regulations by the War Production Board.) Such a stocking, if the fit is imperfect, can be adjusted by an intelligent patient or a stocking saleswoman. If there is edema at the time the stocking first is fitted, there will be a tendency for rings or so-called "rubber tires" to develop around the lower part of the leg. These are unsightly, uncomfortable and conducive to damage of the skin.

Such a tight stocking should be put on over an ordinary silk or rayon stocking, both because this facilitates cleanliness and because the stocking can be drawn on more easily over silk than over skin. Support of this nature will generally be adequate until such time as it is possible to eradicate the cause of edema. If this is not possible, such a stocking will be adequate for from four to eight months, after which time it should be renewed, sometimes it is necessary to spend a week or two reducing the edema before such a replacement.

In the extremely heavy type of leg with much fibrosis, and particularly in the presence of lymphedema, an elastic stocking sometimes is inadequate for proper control. Control may then be obtained by a carefully fitted canvas garter or a legging incorporating stay ribs and made to lace up tightly. The patient should be instructed carefully with respect to the importance of putting this on before getting out of bed in the morning, tightening it firmly and evenly and keeping it on all day.

A delicate skin or a normal skin with considerable fungus infection is likely to break down into weeping dermatitis during the prolonged

course of the adhesive tape treatment. For that reason, every precaution should be taken to hurry the treatment and to control invading organisms. It is striking how rapidly a weeping, itching and abraded skin will recover once the edema is eliminated and the leg is supported by a proper stocking in the daytime and treated with a mildly antiseptic powder at night.

Great stress is laid on the elimination of edema, not merely because it is unsightly and is an invitation to pathogenic organisms but because it is the ground on which the successful varicose ulcer grows. Edema is the principal cause of varicose dermatitis, and if present for a long time it tends to give rise to pigmentation and fibrous tissue, which not only is undesirable in itself but makes more difficult the healing of chance abrasions or ulcers. Incidentally, the fibrosis resulting from long-standing edema makes the treatment of the edema itself more difficult, however, the hard, brawny fibrotic skin and subcutaneous tissue of a person with edema of long duration may be considerably softened by the judicious application of the procedures outlined before.

It is a wise rule to take every precaution against the first appearance of edema, to attack and eradicate it whenever it is found and to keep up the struggle against it even when treatment seems unsuccessful. It is often worth while to measure carefully the ankle of a patient with varicose veins without edema and to repeat the measurement frequently in order that incipient edema may be detected.

Varicose Ulcer—The true varicose ulcer heals spontaneously and rapidly in the absence of edema, venous back flow or vascular insufficiency.

It is well known that the majority of varicose ulcers will heal fairly rapidly with rest in bed and elevation of the foot, if they do not do so, it is generally due to arterial insufficiency, anemia, syphilis or some other complicating factor. Such ulcers as will heal by rest and elevation may be healed with equal or greater rapidity and with considerable economic advantage by relieving them of the edema by the pressure bandage method.

The surface of the ulcer (as well as the rest of the leg) is painted with silver nitrate, and a piece of adhesive tape large enough to adhere to $\frac{1}{2}$ inch (1.27 cm) of skin around the ulcer is placed directly over the surface of the ulcer immediately after a sterile coagulum is formed by the silver nitrate. A large beveled rubber sponge is placed directly over this tape, and cotton, gauze and adhesive pressure bandage are applied as mentioned before. Wherever the ulcer may be, the pressure bandage should extend from the metatarsophalangeal joint to well above the site of the ulcer, it usually is best to carry it right up to the knee.

An untreated inflamed ulcer, particularly if it is directly over subcutaneous bone, often is exquisitely painful. The patient with such an ulcer will rarely accept the pain involved in application of the pressure

bandages The patient should be heavily dosed with codeine and acetylsalicylic acid, and a dressing of weak phenol should be applied directly over the ulcer for half to one hour before any attempt is made to apply the dressing The patient should be given every assurance that the treatment will rapidly eliminate the edema which is the cause of the pain and the tenderness, and he should be provided with enough codeine to insure freedom from pain for two or three days and with a proper sedative for two good nights These patients will rarely mind the second and never the subsequent dressings They are considerably relieved of pain within two days of the application of the first dressing and are so well pleased with this relief that they usually are less disturbed by the various discomforts than are the patients who have not had considerable pain previously

After the ulcer is healed and dry, it is important that care be not immediately discontinued but that adequate support be given until the new epithelium is toughened and until the cause of the edema is otherwise controlled Any method of supportive control of edema is useful, but the most satisfactory is the elastic stocking In the case of a small ulcer on a leg with minimal fibrosis and edema, a two way stretch lastex stocking gives adequate support and is more comfortable and less unsightly than the heavier type When the ulcer has been a large one or is on an indurated leg or one with poor arterial supply, a heavy stocking should be used and for the first four or six weeks after removal of the pressure tape the newly healed area should be covered with a beveled rubber sponge During these weeks, all patients should be instructed to attend carefully to the hygiene of the feet at least twice a day, the stocking should be worn whenever the patient is not recumbent, and a midday rest with elevation of the leg and removal of the stocking should be advised During this time the patient should be informed that neglect of this care of the healing area or failure to give continued care to control or eliminate the varicose state will almost certainly result in a recurrence of the ulcer

Thrombophlebitis—For practical convenience in the consideration of varicose veins, thrombophlebitis may be regarded in three categories, though they are not completely separable

Low Grade Superficial Thrombophlebitis First for consideration is low grade superficial thrombophlebitis, which may or may not migrate a little Patients with varicose veins occasionally will complain of soreness or bruising where small areas of thrombophlebitis develop and involve an inch (2.5 cm) or so of the superficial venous system This rarely gives pain enough to require treatment, but it is necessary to make sure that the complaint is due neither to thromboangitis obliterans (Buerger's disease), if it is occurring in the lower part of the extremities, nor to the onset of a rapid and progressive thrombophlebitis Once

the diagnosis is made with certainty, the patient may be reassured that the lesion of which he complains will not become worse but will gradually resolve itself, though he may have other such lesions elsewhere. He should be told also that thrombophlebitis is beneficial to a certain degree and that it does for him exactly what would be done by an injection of sclerosing solution at that point.

Progressive Superficial Thrombophlebitis Extensive superficial varices occasionally start an area of rapidly progressive superficial thrombophlebitis of the saphenous system. This happens frequently during pregnancy, when the lessening of physical activity tends to slow the flow of blood and perhaps thereby contributes to the thrombotic tendencies already associated with the damage to the veins. It has been suggested also that there may be chemical reasons which make thrombosis more apt to occur in pregnancy. Such a thrombosis commonly starts between 6 inches (15 cm) below and 6 inches above the knee on the inner side in one of the branches of the long saphenous vein, usually the more superficial one. It spreads rapidly, at the rate of from 1 to 6 inches (2.5 to 15 cm) per day. The region is exquisitely tender and painful. It is hot and red, and it may be accompanied with a slight fever and other signs of infection. When this condition occurs in the subfascial branch of the saphenous vein around the level of the knee or slightly above and when it is not seen early in its course, it is sometimes difficult to differentiate from deep thrombophlebitis. Both the immediate and the remote prognosis and also the proper treatment demand that this differentiation be promptly and accurately made. It rests to some extent on careful palpation to determine the exact location of the tissues involved.

When untreated, superficial femoral thrombophlebitis generally progresses up to the saphenofemoral opening but rarely invades the femoral system, nor does embolus commonly occur. For this reason it is allowable to use the conservative and the conventional methods of treatment, namely, rest in bed, elevation, codeine, antipyretics and either hot or cold packs, whichever offers the more relief. Physiologic consideration, no less than common clinical observation, seems to suggest that cold applications, though usually offering more relief, tend to prolong the course of the disease and to delay resolution.

If this condition is seen while the thrombophlebitis is still clinically below the mid thigh, it is advisable to ligate the saphenous vein at the saphenous opening promptly and completely. This gives immediate relief of pain and rapid resolution of the disease and is anticipating a surgical procedure which would be called for later in any case. This has been done successfully as late as the seventh month of pregnancy. No reports are at hand of such intervention after the thrombophlebitis has approached the region of the upper thigh, but since there is no great

hazard from superficial thrombophlebitis and since the pain can to a large extent be controlled by rest, elevation and codeine, it is probably unjustifiable to attempt this procedure near an inflamed area

The disability from acute superficial thrombophlebitis lasts anywhere from a few days to three weeks or more, depending on the extent of the process and the temperament of the patient. Sometimes it can be treated on a purely ambulatory basis, and again it may require time spent in bed, generally, although the limb is more comfortable when elevated, the pain is not severe enough to preclude movement, except in patients who are temperamentally intolerant of pain. This superficial thrombophlebitis, then, is an unpleasant and usually an unimportant incident in the course of the progressive deterioration of the limb with varicose veins, McPheeters,¹³ however, gave a grave prognosis and regarded this condition as the forerunner of an ulcer

Deep Femoral Thrombophlebitis Deep femoral thrombophlebitis, by contrast, is a serious matter, involving a real hazard to life from embolus and a probability of some degree of permanent disability. This condition, known also as milk leg, white leg, phlegmasia alba dolens or marble leg, is well recognized as occurring about the tenth day after a sudden cessation of physical activity. It commonly follows hospitalization for childbirth, abdominal operation, fractures and typhoid. It may also occur after relatively trifling injuries of the foot in which the foot is rested and favored either by the patient's own will or by immobilization of it with the help of adhesive tape.

In the more fortunate patients, deep tenderness will be found in the region of the interosseous membrane in the middle of the leg, this signalizes the beginning of the thrombosis in the deep veins of that part. Ordinarily it is difficult to differentiate this from various and sundry muscle aches and tendernesses which may arise from immobilization or from the discomfort of awkward positions of the patient in bed or under anesthesia. At the other extreme, the condition may be heralded by a fatal pulmonary embolus or by any degree of embolic phenomenon in the lung, even a subclinical infarct which may be discovered at autopsy. However, in the majority of cases, pain, enormous swelling of the whole thigh and leg and signs of infection are the first recognized signs of deep thrombophlebitis and embolic phenomena may or may not follow. After the diagnosis is established, the hazard of a fatal embolus must be recognized. Some of the treatments advocated will be listed here without critical discussion, since it seems that early diagnosis and painstaking care are of greater importance in determining the immediate prognosis than is the particular treatment used. (1) immediate ligation of the femoral vein below the junction of the profunda femoris vein and removal of the clot by aspiration, (2) sympathetic block of the region

13 McPheeters, H. O. *Varicose Veins*, ed. 2, Philadelphia, F. A. Davis Company, 1930

by paravertebral injection of procaine hydrochloride, (3) rest and cold packs, accompanied with elevation, and (4) use of heparin given intravenously or of dicoumarin (3, 3'-methylene-bis-[4-hydroxycoumarin]) given by mouth with a view to increasing coagulation time and thus lessening the risk of extension of the clot, thereby diminishing the chance of embolus

At this time it should be emphasized that the incidence of this disaster is generally associated with immobilization, and in conditions involving rest in bed, whether concerned with varicose veins or not, every possible effort should be made to keep the legs active from the earliest possible moment and to get the patient walking as soon as possible

The discussion of deep femoral thrombophlebitis is included in this consideration of varicose veins because of the poor prognosis of its varicose sequelae. As long as the deep femoral circulation is completely blocked, the superficial saphenous circulation remains as the only venous return from the leg. The increased load is likely to stretch the veins and produce a relative or functional incompetence of the valves of the long saphenous system, and if this continues too long the back pressure which results produces permanent varicose veins

It has not been possible to collect adequate information as to the proportion of all patients with deep thrombophlebitis in whom varicose veins subsequently develop, but a history of thrombophlebitis is fairly common in a clinic devoted to varicose veins, particularly in patients who show obstinate varicose conditions with much edema, with valvular incompetence below the knee and with prominently bulging calves. A patient with this syndrome, that is, much edema, incompetent veins below the knee, a prominently bulging calf and a history of thrombophlebitis, or with any considerable part of the syndrome will have more or less disability with respect to that leg for the rest of his life, for this reason, every effort should be made to follow the patient who has had a deep thrombosis with all possible care in order to try to forestall or delay the development of this disability. A number of suggestions to be discussed are obvious points which merit attention, but there is not any clearcut evidence as to whether the patients receiving good care do better in this respect than those who are completely neglected

The thrombophlebitic patient should be kept in bed with the legs elevated until all edema has disappeared. During this time, once the danger from embolus is safely past, the flow of blood should be promoted by massage, by warmth and, when the pain has subsided, by active movement. When the patient is ready to put his feet to the ground, the affected limb should be protected against venous distention by the application of a firmly fitted elastic stocking extending from ankle to knee and higher if it seems advisable. He should be instructed never to stand or

walk without this support. The patient should be warned against straining, lifting, constipation and pregnancy, and convalescence should be slow with respect to the length of time spent on the feet each day. After three months or thereabouts, when the heavyweight, single way stretch elastic stocking begins to get slack, he should be examined carefully for any of the signs of varicose veins or valvular incompetence and the circulation in his skin should be evaluated. If at this time it is evident that his leg is perfectly normal, he should be advised to wear a lightweight, two way stretch elastic stocking, which gives less support but is much more comfortable than the heavier one. At the end of one year and before the leg is allowed to go entirely without support, the patient should again be examined and made to walk around with the leg tightly bandaged as a method (Perthe's test) of testing the patency of his deep femoral veins. A record of this should be made. If at either of these examinations it seems that varicose or valvular incompetence is developing, the stronger support should be continued and the patient should be warned again of the possibility of permanent disability.

In such patients it is certainly less likely that deterioration of the skin, fibrosis and edema will develop if their incompetent veins are dealt with surgically. It is also possible that the early eradication of the incompetent saphenous system in such patients might contribute toward prevention of the development of the undesirable incompetences below the knee. It is even more probable that some of the valves below the knee actually are damaged in the first instance by the thrombotic process, though their incompetence, of course, does not show up until after the thrombus has resolved and the vessel recanalized. In spite of these indications for haste, it is obvious that no surgical work must be undertaken on the long saphenous system until the deep femoral system has demonstrably recanalized and is capable of carrying the whole venous return from an active limb. Moreover, it is felt that the presence of recent thrombophlebitis suggests the probability of a subacute dormant infection and that at least a year should be allowed to elapse after the first episode before it is safe to attempt surgical treatment on the veins of that leg. It should be added that, although one year is the usually advocated time, there seems to be a tendency to increase the time from one year to one and one-half years.

Although such a patient, if his saphenous system is demonstrably incompetent, can be expected to derive definite prophylactic value from surgical procedures, great care should be taken not to offer him anything which he may interpret as the prospect of a cure. After surgical treatment he should be followed carefully at six month intervals. Unusual care should be taken that any distended vein accessible from the surface, either by inspection or by palpation, is obliterated by sclerosing fluids, and every attempt should be made to observe the earliest signs of the onset of edema and to control it by every method available.

TREATMENT OF AN UNUSUAL SUBDURAL HYDROMA (EXTERNAL HYDROCEPHALUS)

WALTER E. DANDY, M.D. †

BALTIMORE

WHEN cerebrospinal fluid progressively accumulates over the surface of one or both cerebral hemispheres, the condition is known as external hydrocephalus, or subdural hydroma. It results from a tear in the arachnoid membrane, through which the fluid pours into the subdural space, where it cannot absorb. Moreover, when a peripheral branch of the subarachnoid space is involved the fluid is trapped in the subdural space as by a valve, the compression of the arachnoid by the fluid closing the opening and preventing its return into the subarachnoid space, although the fluid can and does continue to pass into the subdural space. It is now known that cerebrospinal fluid can be absorbed only in the subarachnoid space and from the capillaries of the pia-arachnoid. It cannot be absorbed in the subdural space (except in minimal amount). The end result of this sequence of events is a large quantity of fluid over one or both cerebral hemispheres, and the cerebral hemisphere or hemispheres are pushed downward toward the base of the brain.

There are two types of external hydrocephalus. 1 Congenital type. It is a sequel of internal hydrocephalus of the communicating type. Either from a congenital defect in the wall of the cisterna chiasmatis or from continued pressure of fluid in this cisterna the membrane ruptures and fluid pours over both cerebral hemispheres. The results are a tremendous bed of fluid in a greatly enlarged head and two tiny cerebral hemispheres crowded to the base of the skull. Valve action is absent in this type. An excellent example of this type of external hydrocephalus is produced at operation by an opening in the anterior part of the floor of the third ventricle for internal hydrocephalus. The fluid passes into the subdural instead of the subarachnoid space, and the internal hydrocephalus is then transformed into external hydrocephalus. I have since learned that by making the opening farther back in the floor of the third ventricle the fluid can be diverted into the subarachnoid space and this complication will be avoided. 2 A post-traumatic type. In this type the arachnoid membrane is torn beyond the cisterna, fluid then pours into the subdural space. This type is usually unilateral, since a peripheral branch of the arachnoid is involved and the fluid accumulates over one hemisphere only. Doubtless, many of the patients in such cases are

† Dr. Dandy died April 19, 1946.

cured spontaneously when the arachnoid tear heals. Others require evacuation and drainage of the fluid for a short time until the arachnoidal wound closes. The valve action in the causation of subdural hydroma should be stressed because of its importance. An opening in a cisterna will not induce a subdural hydroma, because the fluid is in free communication with the cisterna and will not therefore accumulate under pressure. The cisterna chiasmatis is routinely opened in many intracranial operations and never causes subsequent trouble.

The case presented here is one of the latter type but of unusual severity, i. e., despite repeated taps and drainage the accumulation of fluid continued, and without improvement. The entire hemisphere was depressed 5 or 6 cm (fig 4*b*) from the dura, and a single vein (the rolandic vein) crossing from the hemisphere to the longitudinal sinus was stretched over the space. This type of case is doubtless rare, it is the only one I have seen resulting from trauma and assuming such magnitude and the only one that has not been amenable to repeated taps or temporary drainage, nor do I know of any other cases in the literature.

REPORT OF A CASE

D H, an ill-looking, sparsely nourished, very drowsy boy aged 2 $\frac{1}{4}$ years (fig 1), entered the Johns Hopkins Hospital Aug 24, 1944. He complained of severe generalized headaches. He had been well until April 1944 (four months previous), when he fell down a flight of steps. He was not unconscious, but the next day he was dizzy and vomited once. He was irritable for some time and was given phenobarbital. Two months later he fell off a table and immediately vomited and continued to vomit throughout the day. His physician found bilateral papilledema and increased reflexes on the right side. (The papilledema could not have developed so quickly and must therefore have been the sequel of the fall two months earlier.) He was taken to Dr. Joseph P. Evans, of Cincinnati, who suspected a subdural hydroma, he tapped the subdural space in the occipital region of the left side, found a large amount of subdural fluid and drained it. When this was unsuccessful, he performed a left subtemporal decompression and again drained the fluid. Next, a left craniotomy was done over the decompression, which was tight and full. The fluid was evacuated, but it subsequently continued to collect under pressure.

The neurologic examination showed only a full and tight subtemporal decompression, a floating bone flap, hyperactive reflexes on the right, a positive Babinski sign on the right and a slight palsy of the left sixth nerve. There was no papilledema.

Operation—On Sept. 13, 1944, air was injected into the spinal column, 300 cc. of fluid was removed and this amount of air injected. The ventricular system filled and was reduced in size and pushed to the right (figs 2 and 3). A great bed of air covered the left hemisphere, which was also separated from the falx (figs 2 and 3).

On September 15, the old craniotomy wound was reopened. The bone flap was lying loose and nowhere attached to bone. A tremendous amount of fluid covered the entire left hemisphere and depressed it fairly uniformly 5 or 6 cm.

below the dura (fig 4), the hemisphere was separated from the falx. A thin avascular membrane lined the inner surface of the dura. Only one vein, the rolandic, crossed from the hemisphere to the longitudinal sinus. It was intact, but it was attenuated from its long stretch. The entire outer surface of the hemisphere could be inspected, and no sign of a tear in the meninges could be seen nor could any fluid be seen passing from the sylvian fissure or anywhere on the surface of the brain. The cisterna at the chiasm was normal but tore during the retraction. By elimination, it was suspected that the rupture of the arachnoid was along the falx, and this could not be inspected satisfactorily. The arachnoid along the falx had been suspected before operation because on



Fig 1—Photograph of patient before the operation, showing bulging decompression due to the pressure of the subdural hydroma. Note the slight palsy of the left sixth nerve.

a few occasions after tumors had been removed from the falx the fluid continued to pour out for a rather long period, and on two or three occasions it had been necessary to iodinize this membrane to hasten closure of the fistula. However, in this case there was no way by which the location of the probable fistula in the arachnoid could be determined. With a cotton pledget immersed in 3.5 per cent iodine, the surface of the hemisphere adjacent to the falx was swabbed from the frontal to the occipital pole (fig 4A). After about a minute, the iodimized area was washed with isotonic solution of three chlorides. The opening in the

cisterna chiasmatis (opened at operation) was also swabbed with iodine, the optic nerve being protected with a piece of cotton

Subsequent Course—The decompression remained full and tight until the thirteenth day, when it appeared smaller and softer, and during the succeeding ten days it steadily receded. On the twenty-fifth day the decompression suddenly became full and tight, the fluid contained 500 cells, with 80 per cent polymorphonuclears, the temperature rose to 103.8, the pulse rate was 144 and the white blood cell count 24,360. It was thought that the fluid had become infected from the subdural taps that had been made from time to time, but no organisms grew from the subdural fluid, the patient had just recovered from a severe cold. He was given sulfadiazine therapy, and he quickly improved. The decompression again became soft. Five weeks after operation the decompression was flat, and the patient was active and happy. He was discharged Oct. 31, 1944.

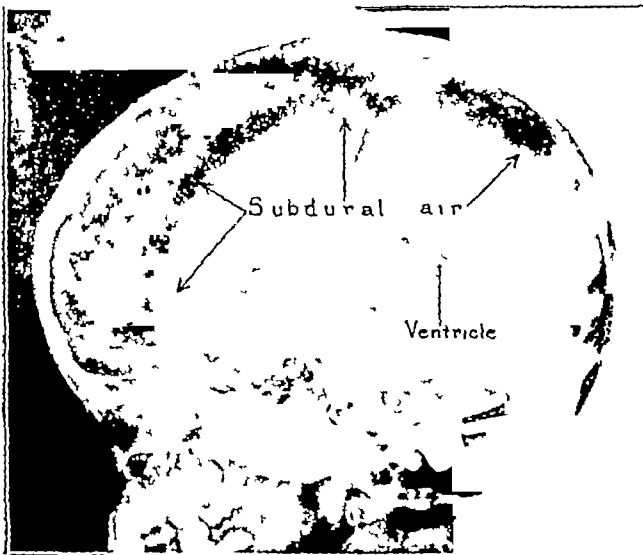


Fig 2—Lateral view (retouched) of encephalogram showing the tremendous accumulation of fluid (air) in the subdural space and the uniformly compressed lateral ventricle

Subsequent Note—On March 25, 1945, Dr. Evans stated, "I think that one must conclude that the boy is a normal child, but I still want to speculate as to whether you or Nature should be given credit for the result."

Since there is a tendency for spontaneous healing of subdural hydromas, Dr. Evans' query is quite natural. However, this patient had gone four months, and neither repeated taps nor drainage had been at all helpful. Moreover, the closure of the fistula had occurred promptly, i. e., thirteen days after operation, when the decompression became soft. This is about the time one would expect a fistula to close from adhesions induced by iodine. It is true that a definite fistula was not disclosed because it was in a part of the subarachnoid space that

could not be inspected. Whether or not it could have been actually seen if inspection were possible is doubtful. However, it appeared that this was the logical place to expect the leak, since the meninges elsewhere were intact and because from past experiences it had been learned that openings in the subarachnoid space along the falx were more refractile to spontaneous closure than elsewhere. Since the fistula could not be seen, it was necessary to iodinize the entire area along the falx to insure its inclusion.



Fig. 3—Anteroposterior view (slightly retouched). This shows *A*, the triangular falx at the longitudinal sinus, *D*, the falx elsewhere (these shadows are set off by the air in the subdural space), *B*, a small amount of air along the falx on the right (opposite) side, *C*, unexplained shadow, doubtless also set off by the air in the subdural space (this cannot be seen in the lateral view), *E*, lateral and third ventricles pushed to the right side, *F*, defect in bone, created when flap was made, and *G*, subdural air on the left side.

INTERPRETATION OF ENCEPHALOGRAMS

There are some details in the air plates—particularly in the anteroposterior views—that are difficult to interpret, they may or may not be significant. It has been stated that in this case the external hydrocephalus (hydroma) was unilateral. Subdural taps on the right side encountered no fluid, and there was no fluid over the right cerebral

hemisphere. However, in the anteroposterior view there appears to be a small pocket of air between the falx and the hemisphere on the right side (fig 3 *B*), with stereoscopic vision, this can be located well anteriorly and appears to be an isolated pocket. It is possible that this shadow may not be on the right side but may be part of the left air shadow pushed over to the right side. However, to the left of this air shadow is a triangular opaque shadow of the falx (fig 3 *A*) at the longitudinal sinus. It is outlined because air is on both sides, moreover, it is in the exact midline of the skull.

There are two other features that have been consistently present in repeated plates, and the explanation for them is not too clear. 1 There

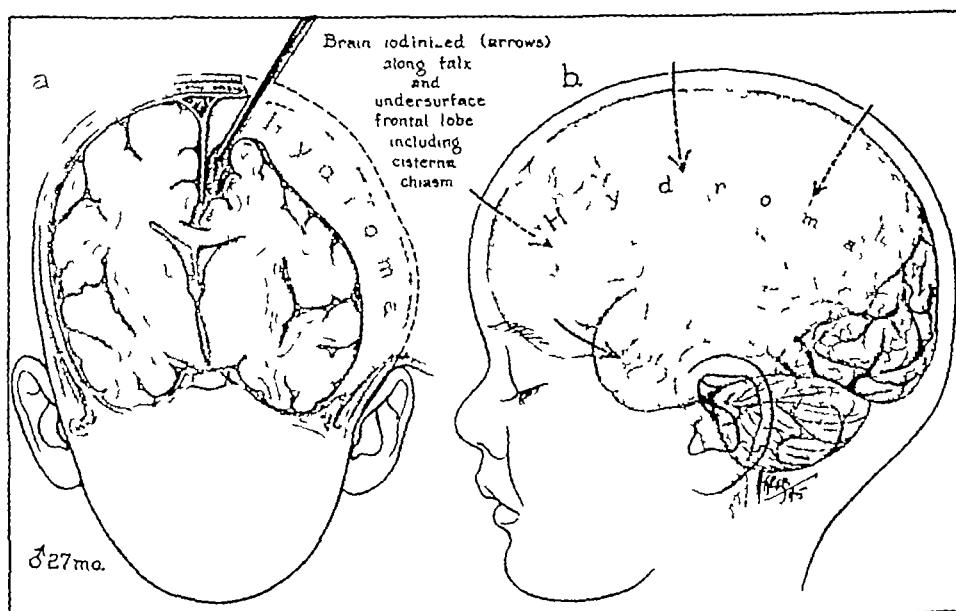


Fig 4—Drawing showing (b) the subdural collection of fluid and (a) the method of swabbing the mesial surface of the hemisphere with iodine to promote adhesions and closure of the fistula.

is a sharply outlined line through the center of the head (anteroposterior view), with a slight bulge to the right (fig 3 *D*). This is almost certainly the falx and is continuous with the triangular shadow of the falx noted above. But, unless there is air on both sides of the falx, there is no reason that the falx should be so sharply delineated. The probable explanation is that there is air on both sides of the falx, but it cannot be seen in the roentgenogram. A shadow of this kind I have not seen before.

2 The most difficult shadow to interpret is an oblong opacity in the anteroposterior view (fig 3 *C*), it is about 1.5 cm long and 1 cm wide and is attached to the midline linear shadow and is on the right side.

With stereoscopic vision this can be seen well anteriorly in the frontal region. Repeated attempts have failed to locate this shadow in the lateral view. It, therefore, is not a calcification but must be a soft tissue shadow, thrown in relief by the surrounding air, which is not visible. The significance of this opaque shadow is not clear, but the question arises whether it may be a congenital lesion, perhaps a precursor of a subsequent calcification of the falx, and possibly indicates the point at which the rupture of the meninges has occurred. My guess would be that this may be true, but proof is lacking. Subsequent cases may throw additional light on these findings.

It will be noted in the lateral view that the left lateral ventricle is small and depressed (fig 2) by the downward displacement of the hemisphere. There is a pronounced shift of the ventricular system to the right (fig 3 *E* [anteroposterior view]).

RELATION OF SUBDURAL HYDROMA TO ABSORPTION OF CEREBROSPINAL FLUID

This case is also of interest because of its bearing on the place and manner of absorption of cerebrospinal fluid. There are two schools of thought on this point: (1) that the fluid is absorbed from the entire subarachnoid space and into the capillaries of the pia-arachnoid (this is my own view and is based on experiments that have been described), (2) that the fluid passes into the longitudinal sinus by way of the pacchionian granulations or other preformed stomas in the walls of the longitudinal sinus (this is the conception of Weed).

If one views the condition superficially, the tremendous bed of fluid over the cerebral hemisphere in this patient might appear to be an ideal example of the effects of closure of openings through the pacchionian granulations or their equivalents, *i. e.*, postulated microscopic stomas in the longitudinal sinus. However, this conclusion is not so simple as it seems, for the fluid is in the subdural space and not in the subarachnoid space. If such postulated openings were obstructed, the fluid must be in the subarachnoid space and must cover the hemisphere, for it must dam back from the point of obstruction. Not only is that not true in this case, but it might be added that in well over a hundred of my cases that have come to operation and necropsy such a condition has never yet been observed.

Moreover, if this bed of fluid in the subdural space were due to blockage of such hypothetical openings, there could be no possibility of curing the condition. Certainly the openings could not be reestablished and regain function after being closed for four months. On the other hand, the separation of the hemispheres from the longitudinal sinus in this case is precisely like that in the experiments on dogs, in which the hemispheres are separated from the longitudinal and transverse sinuses

on both sides (there is only one attachment, i. e., the rolandic vein, and there are no pacchionian granulations) and without the slightest effect on the absorption of cerebrospinal fluid, nor does fluid accumulate over the cerebral hemispheres thereafter

The deduction is clear that the postulated openings in the longitudinal sinus have no foundation, in fact, they do not exist. The absurdity of openings into veins is shown by the fact that blood would pass out of them into the subarachnoid space as easily as fluid could pass into them. Veins just do not have openings in their walls. Cerebrospinal fluid is absorbed from the capillaries of the pia-arachnoid, and its absorption is precisely similar to that of fluids elsewhere in the body.

DIAGNOSIS OF ACUTE APPENDICITIS IN THE PRESENCE OF DIARRHEA

E L. KEYES, M D
AND
M M COOK, M D
ST LOUIS

IN THE presence of diarrhea the differential diagnosis of acute appendicitis from enteritis is difficult. Even in the absence of diarrhea acute appendicitis may be mistaken for enteritis because both diseases begin with pain not unlike a sensation of impending diarrhea and because the physical and the laboratory findings may be almost identical in the two diseases during the early stage (cases 2 and 3)

TABLE 1—*Differential Diagnosis of Early Acute Appendicitis and Enteritis*

Point	History	Acute Appendicitis, Early Stage	Enteritis
1	Pain	Persistent in midline despite defecation	Varying situation, intermittent relieved by defecation completely if temporarily
2	Bowel urge	Associated with pain persists despite defecation	Associated with pain relieved by defecation completely if temporarily
3	Diarrhea	Uncommon, subordinate to bowel urge	May dominate clinical picture
4	Nausea	Subordinate to bowel urge occurs subsequent to pain	May exceed bowel urge may precede pain
5	Vomiting	Present in less than half the cases	Present in over half the cases
Physical Findings			
6	Tenderness	None in some cases, epigastric, perumbilical or rectal in others	None in some cases variable in others bowel sounds may be hyperactive
Laboratory Findings			
7	Fever	None or slight	Same
8	White blood cell count	Usually over 10,000	Lower average

Points 1 to 4 under acute appendicitis constitute the "gas stoppage sensation"

Ultimately, the diagnosis may depend largely on the results of an orderly and detailed analysis of the history of the case, which brings out points 1 to 4 listed in table 1. The differential points are as follows. The first pain of acute appendicitis is persistent, and that of enteritis is intermittent. The first pain in both ailments is associated with a bowel

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urge,¹ but pain persists despite defecation in the early stage of acute appendicitis whereas in enteritis defecation relieves the pain completely if temporarily. Moreover, in early acute appendicitis the downward urge to defecate exceeds the upward urge to vomit whereas the converse often occurs in enteritis. Finally, diarrhea when present often dominates the clinical picture in enteritis, whereas early in acute appendicitis it is the bowel urge, not the diarrhea, which chiefly occupies the attention of patients. Such are the points we wish to make in this paper.

REPORT OF ILLUSTRATIVE CASES

Failure to appreciate points 1 to 4 (table 1) caused dangerous delay in diagnosis, for diarrhea clouded the clinical picture of acute appendicitis.

A consultant not familiar with points 1 to 4 in table 1 saw the patient in the following case during the second day of illness, on Monday evening (chart 1, C_1), with a clinical picture as given in the following report:

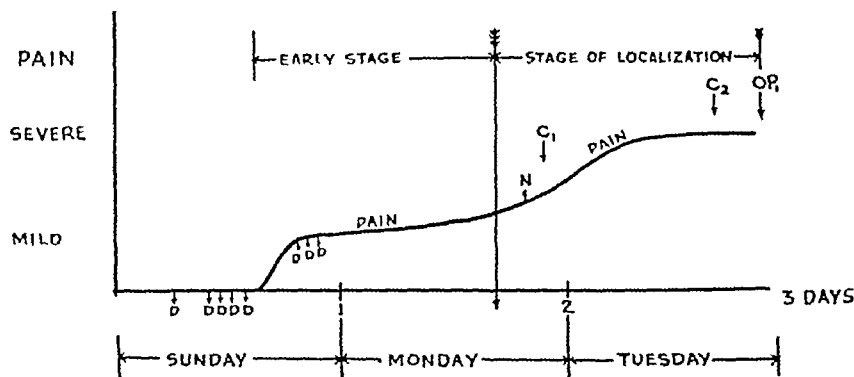


Fig 1 (case 1)—Pain chart in acute appendicitis. *D* indicates diarrhea, *N*, nausea, C_1 , first consultation, C_2 , second consultation, and *Op*, operation. Note that pain persists despite diarrhea.

CASE 1—W S B, a 41 year old man, was admitted to the hospital Nov 14, 1944.

Previous History—The patient had had diarrhea for a day one week previous. His wife had also had diarrhea then.

Present Illness—Diarrhea recurred the day before consultation. It was painless at first, but that afternoon it was associated with what the patient called "a little knot or tight feeling just below the belly button." The patient ate a heavy supper Sunday night and then lay down because, he said, "the tight feeling persisted." After supper, he went to the toilet three times and "had a loose movement each time, with no relief." He took camphorated tincture of opium and magnesium hydroxide. Monday afternoon, before the time of his first consultation, the pain began to shift to the right lower quadrant of the abdomen and the patient felt nauseated.

1 Keyes, E L. Diagnostic Features of the First Pain of Acute Appendicitis, *J Missouri M A*. 41 30-33 (Feb) 1944.

Physical Findings—There were tenderness and muscle guard in the right lower quadrant of the abdomen

Laboratory Findings—The white blood cell count was 14,000

Comment—It was the history of the presence of diarrhea that alone raised doubt in the mind of the first consultant as to the validity of the diagnosis of acute appendicitis on Monday evening (chart 1, C_1). Otherwise the clinical picture was typical of acute appendicitis. The presence of diarrhea, however, suggested enteritis as a possible diagnosis, a supposition that was strengthened by the fact that both the patient and his wife had had enteritis the week before. These doubts caused a day's delay in diagnosis, for the significance of the points in table 1 was not fully appreciated by the first consultant.

By the next day all doubts as to diagnosis were dispelled (chart 1, C_2). Signs of localization had become unquestioned. A surgeon (E. L. K.) was called, and immediate operation was recommended. The appendix was found completely gangrenous and ruptured, and peritonitis was present. The appendix was removed. Recovery was slow.

TABLE 2—Criteria for the Diagnosis of Acute Appendicitis in the Early Stage

History	Midline pain associated with bowel urge persisting for hours despite defecation and despite diarrhea the downward urge to defecate exceeds the upward urge to vomit, this syndrome is named the "gas stoppage sensation", pain precedes nausea, fewer than 50 per cent of patients vomit
Physical findings	Tenderness in the epigastrium, about the umbilicus or by the rectum, no tenderness whatsoever in some cases
Laboratory findings	Temperature normal or slightly elevated pulse normal or slightly accelerated white blood cell count over 10,000 indicates acute appendicitis histologically, white blood cell count under 10,000 indicates subacute or obstructive appendicitis or lesser changes histologically ²

Undelayed diagnosis was made in the early stage of a comparable case of acute appendicitis, despite the possibility of impending diarrhea, by use of the criteria in tables 1 and 2

The patient in the following case (case 2) was first seen (chart, 2, C_1) by one of us (E. L. K.) at a time comparable to the time of first consultation in the previous case, namely, the second day of illness, and with a comparable history with respect to the passage of many stools. Despite the fact that this patient had had five stools, enteritis or impending diarrhea were not thought the likely diagnosis, but instead a diagnosis of acute appendicitis was made, although signs of localization as yet had not appeared. Definitive and undelayed diagnosis proved possible by use of the criteria in tables 1 and 2.

Particular emphasis in the diagnosis in case 2 was placed on the history of prolonged persistence of the midline pain, pain which persisted over twenty-four hours, pain which was associated with the urge to defecate and pain which persisted despite the five bowel movements. Pain, moreover, was midline in situation. Note, before the findings in the case are divulged, that the criteria in tables 1 and 2 are fulfilled by the clinical picture, which may now be presented.

CASE 2—B B, a 22 year old man, was admitted to the hospital June 24, 1944

Previous History—On Thursday, the patient was constipated and took a laxative. There was no pain then.

Present Illness—On Friday, mild "generalized cramps" began. They persisted during Saturday, and the patient on that day passed five solid stools. Before supper Saturday night, he said, he "didn't feel so good" so he "sat on the toilet," thinking that if he "could pass gas it would relieve" him but, although gas was passed, pain persisted and after the patient had eaten a good supper, he said, "it kept bothering me more and more," becoming "just a continual gripe" about the umbilicus and the epigastrium. Just before the first consultation, he felt nauseated.

Physical Findings—There was slight tenderness in the epigastrium and in the rectum but none elsewhere.

Laboratory Findings—The patient's temperature was 101.2 F and the white blood cell count 10,100.

Comment—Immediate operation was recommended (E. L. K.) on the basis of these criteria (table 2), but the patient requested a second opinion, which could

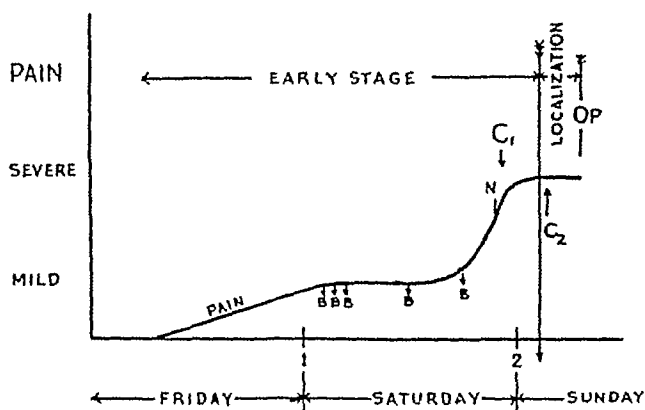


Fig 2 (case 2)—Pain chart in acute appendicitis. B indicates bowel movement, N, nausea, C₁, first consultation, C₂, second consultation, and Op, operation. Note that pain persists despite defecation.

not be obtained for some hours, operation nevertheless was scheduled. During the intervening hours, the pain shifted to the right lower quadrant of the abdomen and signs of localization appeared. At operation the appendix was found greatly distended by increased pressure within the lumen, resulting from its complete blockage by a large fecalith impacted in the base. Following appendectomy, recovery was rapid. The histologic diagnosis was acute appendicitis.²

CRITERIA FOR THE DIAGNOSIS OF ACUTE APPENDICITIS IN THE EARLY STAGE (TABLE 2)

The criteria in table 2 often warrant the early diagnosis of acute appendicitis prior to the time of localization, in our experience. These criteria are not widely taught. Ordinarily, it is taught that diagnosis

² Histologic diagnoses in the cases reported in this paper made by Dr. N. A. Womack and Dr. Charles Eckert of the Department of Surgical Pathology.

should be delayed until the criteria for the later "stage of localization" become manifest

Appendicitis passes through a state of pathologic development which may roughly be divided into two stages—an early stage and a later stage of localization. In the early stage inflammatory changes remain confined to the appendix, Wilkie³ and Wangenstein⁴ have shown experimentally how inflammation and infection can arise from obstruction of the lumen of the appendix. In the later stage of localization, inflammation spreads from the appendix to the mesoappendix and the parietal peritoneum.

The early stage corresponds generally to the "early afebrile stage" of Wilkie³ and to the stage in which Eusterman⁵ said "a vague

TABLE 3—*Time Element in Differentiating Enteritis from Early Stage of Acute Appendicitis*

A Time Elements of the Pain of Enteritis*						
	Case 5	Case F D	Case 3	Case T H G	Case 7	Average
Individual cycle of pain						
Duration of each pain	½ min	3 to 4 min	5 to 10 min	20 min or 10 sec		
Duration of pain free intervals	5 min	3 to 4 min	20 to 30 min	60 min or 30 sec		
Total duration of attack	6 hr	11 hr	12 hr	10 hr	7 hr	9 hr
B Total Duration of Attack of Enteritis Compared with Duration of the Early Stage of Acute Appendicitis†						
	Enteritis (5 Cases)		Acute Appendicitis, Early Stage (20 Cases)			
Average duration	9 hr		20 hr			
Shortest duration	6 hr		1 hr			
Longest duration	12 hr		3 days			

* Cycles of pain are irregular. The average attack lasts nine hours.

† Pain persisted on the average of twenty hours in the early stage of acute appendicitis.

dyspepsia may precede for some time an acute localizing seizure." The early stage lasts twenty hours on the average (table 3). In some patients it lasts an hour or less. In others it may last two or three days (case 1).

Prolongation of the early stage may result in dangerous delay in diagnosis (case 1) or even in death (Devine⁶). Authors have criticized

3 Wilkie, D. P. D. Acute Appendicitis and Acute Appendicular Obstruction, *Edinburgh M. J.* **25** 308 (Nov.) 1920.

4 Wangenstein, O. H., and Dennis, C. Experimental Proof of the Obstructive Origin of Appendicitis in Man, *Ann. Surg.* **110** 629-647 (Oct.) 1939.

5 Eusterman, G. B. Notes on the Dyspepsias, with Special Reference to Diagnosis, *J. Missouri M. A.* **9** 329-332, 1913.

6 Devine, H. The Surgery of the Alimentary Tract, Baltimore, Williams & Wilkins Company, 1940.

the lack of accepted criteria for diagnosis in the early stage. Regarding current criteria for diagnosis, which are criteria for diagnosis in the later stage of localization, Zachary Cope⁷ commented, "The so-called typical symptoms of appendicitis as given in textbooks often indicate a somewhat advanced stage of the condition." Delay in diagnosis until the third day is common and is also dangerous because the appendix ruptures on the third day on the average.⁸

To make the diagnosis of acute appendicitis in the early stage requires great reliance on the results of careful analysis of the history of the case, for the early physical findings are inconclusive (table 2). Eusterman says that in "appendiceal dyspepsia, pain is not referred to McBurney's point, and often no appendiceal tenderness can be elicited." Leukocytosis, however, is usual, the count often being over 10,000.

So characteristic do we believe the pain of acute appendicitis to be in the early stage that it has been given the name of the "gas stoppage sensation." The reason for this inadequate name is that a patient is apt to feel that if he "could pass gas" he might obtain relief from the "continual gripe" (patient 2) or "tight feeling" (patient 1) or whatever name the patient may give the first pain.

The "gas stoppage sensation" comprises persistent midline pain associated with a bowel urge, which causes patients to seek the toilet and to take laxatives.⁹ Pain persists for hours or for days. Pain persists despite defecation, despite diarrhea and despite the passage of gas by rectum. The downward urge to defecate exceeds the upward urge to vomit. So mild may be the sensation as to be overlooked by some patients. It is severe in other patients, often made worse by eating, by exertion and by catharsis. The "gas stoppage sensation" disappears usually as localization begins. It is a subjective sensation. It is a symptom. It is not a physical sign.

The "gas stoppage sensation" is claimed to be characteristic of the early stage of acute appendicitis for the following reasons. Three surgeons (E. L. K. included) and one internist have personally felt the sensation prior to the removal of their own acutely inflamed or gangrenous appendixes. Dr. P. O. Thomas and one of us (E. L. K.) recently elicited a history of the "gas stoppage sensation" at onset in 58 of 76 successive patients with acute appendicitis histologically proved at the St. Louis City Hospital and in private practice. We

7 Cope, Z. *The Early Diagnosis of the Acute Abdomen*, ed. 8, London, Oxford University Press, 1940.

8 Keyes, E. L. *Death from Appendicitis. The Mortality from Appendicitis and the Causes of Death Following Appendicitis*, *Ann. Surg.* **99** 47-68 (Jan.) 1934.

9 Keyes, E. L., Jr. *The Sensation of Gas Stoppage During the Onset of Acute Appendicitis, with Illustrative Cases*, *Surgery* **17** 270-283 (Feb.) 1945.

found it absent chiefly in children under 7, too young to comprehend the three questions used to elicit it, and otherwise in patients with low intelligence quotients, as pointed out by Dr Mitchell Johnson. Dr John Akin found it present at onset in most of the cases of acute appendicitis at Barnes Hospital. From these calculations one may expect to find histories typical in this respect in about 3 or 4 patients out of every 5.

Almost as striking as the presence of the sensation at onset of acute appendicitis is its consistent absence in acute conditions within the abdomen of other types, with the exceptions hereafter noted. The "gas stoppage sensation" has been found absent in every patient with perforated peptic ulcer, renal disease, gallstone colic and acute cholecystitis with but one exception, in a woman with acute cholecystitis. The sensation has been found absent in many cases of acute salpingitis at the St. Louis City Hospital by Dr Lyle Bachman, though one of us (E L K) has noted two exceptions to this rule. The sensation

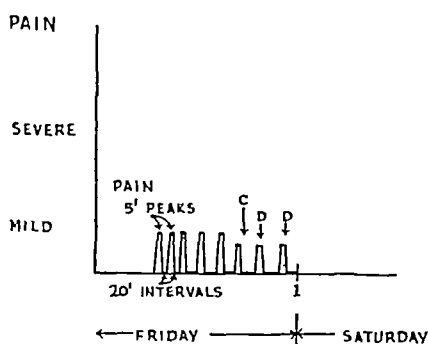


Fig 3 (case 3) —Pain chart in enteritis. C indicates consultation and D, diarrhea. Note that pain is relieved temporarily by defecation.

has been found absent in all but 2 cases of ruptured ectopic gestation (E L K). It has been found absent in 150 cases of enteritis (M M C), as we are in the process of discussing. However, in one surgical condition it does occur consistently at onset (E L K), namely, at onset of acute intestinal obstruction of the small bowel, although in such cases vomiting rapidly comes to exceed the downward urge.

Pain in enteritis is intermittent (table 1 point 1)

CASE 3—J W G, a man aged 22, was admitted to the hospital Feb 16, 1945.

History—The patient said that in the morning, about 9 o'clock, he noticed "intermittent pains, which would hurt five or ten minutes and then disappear for a while." Disappearance of pain was complete between pains. The pain was situated just below the umbilicus. Bowel urge accompanied the pains, and there was anorexia.

Physical Findings—There was tenderness about the umbilicus but no tenderness by rectum.

Laboratory Findings—The patient's temperature was 98.6, and the white blood cell count was 13,300, with shift.

Comment—At the time of the first consultation (chart 3 C), because pain was associated with the bowel urge and because there was tenderness about the umbilicus and leukocytes with shift, a diagnosis of acute appendicitis in the early stage was considered by us. However, the pain was intermittent. Pain lasted only five or ten minutes, then there was complete relief. Moreover, the attack was but six hours old. Consequently, the diagnosis of enteritis was made. The diagnosis proved correct when later that night the patient passed two diarrheal stools (chart 3, DD). By the next morning he was completely well.

One year later, on Feb. 25, 1946, he was operated on for acute appendicitis (E.L.K.). The pain of his attack of acute appendicitis differed from the pain of his attack of enteritis, he said, with respect to the points discussed in this paper.

Compare the clinical picture in cases 2 and 3, and note that the main difference is with respect to the pain. The pain in this case of enteritis (case 3) was intermittent. The pain in the patient with appendicitis (case 2), by comparison, was persistent. He said that it was "just a continual gripe," lasting over twenty-four hours.

The difference between "intermittent" and "persistent" as used in this paper is a difference in periods. Table 3 indicates this point. The intermittent pain of enteritis lasts a matter of minutes and then disappears again for a matter of minutes. The persistent pain of beginning acute appendicitis lasts for many hours or even for some days. Only in recurrent appendicitis does pain remit completely and then recur. This is not intermittent pain but rather, as Eusterman called it, "a continuous pain" which occurs in "distinct prolonged attacks." To clarify this point it will be necessary to present another case (case 4).

*Pain in recurrent appendicitis occurs in distinct prolonged attacks*⁵

CASE 4—B. F. S., a 24 year old man, was admitted to the hospital June 9, 1945.

History—Wednesday, after eating dinner, this patient said that he noticed a "full feeling in the stomach" and then a "dull aching in the epigastrium." Next, he said, he passed a diarrheal stool, "with no relief from pain." Later he was nauseated. The first attack lasted eighteen hours, from Wednesday to Thursday, then it subsided, and the patient felt no pain whatever. Three further distinct attacks occurred, lasting four, eleven and eighteen hours respectively. Between attacks, pain disappeared.

Physical Findings—There was tenderness in the epigastrium but none elsewhere. The rectal examination revealed no abnormalities.

Laboratory Findings—The temperature was 99.2 F., and the white blood cell count was 11,600, without shift.

Comment—A diagnosis of recurrent appendicitis was made by us at the time of first consultation, Saturday afternoon (chart 4 C), by use of the criteria in table 2. Immediate operation was recommended, but pressing schoolwork required its postponement. Meanwhile, the patient being under close observation in the hospital, the attack subsided. The next week operation was performed, the

appendix still seemed boggy, it contained a fecalith and was removed. Histologically, the diagnosis was chronic obstructive appendicitis, and there was evidence of recent inflammation.²

Pain in enteritis is relieved by defecation completely if temporarily

CASE 5—T E, a 23 year old man, was admitted to the hospital in June 1944

History—This patient noted "cramps in the lower part of the abdomen which would last thirty seconds and which occurred periodically at intervals of about five minutes" He said, "I had no symptoms between cramps After about forty-five

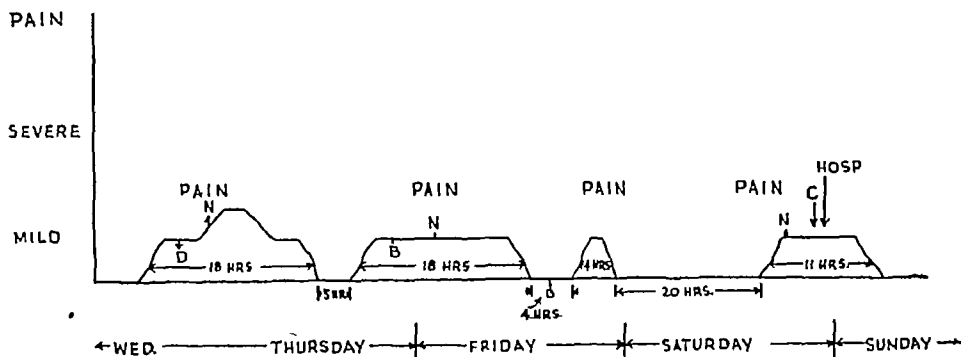


Fig 4 (case 4) —Pain chart in recurrent appendicitis D indicates diarrhea, N, nausea, B, bowel movement, C, consultation, and Hosp, hospitalization. Note how many hours pain persists

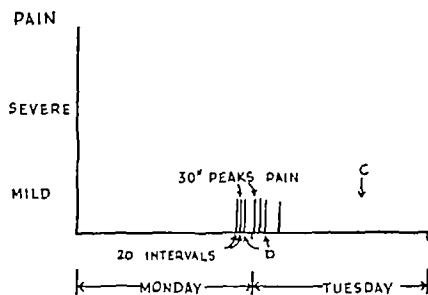


Fig 5 (case 5) —Pain chart in enteritis D indicates diarrhea and C, consultation Note that pain is relieved temporarily by defecation

minutes, I defecated After moving my bowels, I felt completely relieved of symptoms" The cycle of pain was then repeated, and he said, "Funny thing, after I defecated I felt fine."

Physical Observations—There were no abnormal findings

Laboratory Observations—The condition of the patient was normal

Comment—A diagnosis of enteritis was made Operation was not performed The first consultation was twenty-four hours after onset. Note that "after moving the bowels, I felt completely relieved of symptoms," said the patient.

Pain in the early stage of acute appendicitis persists despite defecation and despite diarrhea (table 1, point 2)

CASE 6—H W, a 24 year old man, came to the hospital Jan. 23, 1945

History—This patient said, "At 11 a m today I noticed cramplike pain in the epigastrium" After eating lunch "I tried to have a bowel movement, and it

was extremely small, cramps became increasingly worse" Numerous stools made him think that "I was going to have diarrhea," yet pain persisted and he "still felt like I had to go to the toilet." He vomited once, but the downward urge predominated The pain shifted to the right lower quadrant of the abdomen

Physical Findings—There was tenderness, muscle guard and rebound at McBurney's point There was also rectal tenderness

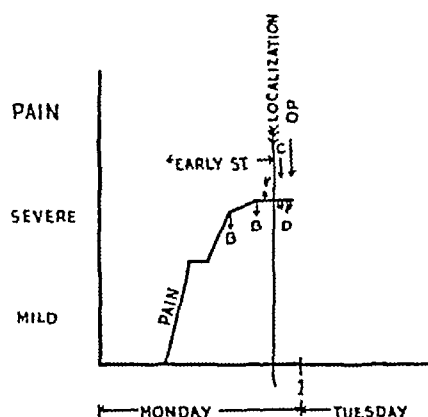


Fig 6 (case 6)—Pain chart in acute appendicitis B indicates bowel movement, V, vomiting, C, consultation, and Op, operation

TABLE 4—*Differential Diagnosis of Acute Appendicitis in the Stage of Localization from Enteritis*

Point	History	Acute Appendicitis, Late Stage	Enteritis
1	Pain	Shifts to right lower quadrant of the abdomen may shift elsewhere, may fail to localize	Rarely shifts
2	Bowel urge	Usually disappears	Usually persists intermittently
Physical Findings			
3	Tenderness	In right lower quadrant of the abdomen, increasing toward McBurney's point may be atypically situated, occasionally absent, rectal tenderness common	Usually less pronounced and more variable in situation bowel sounds may be hyper active
4	Spasm and rebounds	Common, cough and rebound tenderness common ¹²	Rare
Laboratory Findings			
5	Fever	Normal to 102, occasionally higher	Lower or higher
6	White blood cell count	Average 15,100 to 15,900 (Ochsner, A, and Johnston G H Surgery 17 878, 1945)	Average 12,400 ²¹

Laboratory Findings—The patient's temperature was 98 and the white blood cell count 23,800, with shift.

Comment—A diagnosis of acute appendicitis was made within twelve hours of onset, by criteria in tables 2 and 4 Appendectomy was performed immediately The appendix was grossly and histologically inflamed acutely The patient made a rapid recovery

Persistence is a well recognized attribute of pain in the early stage of acute appendicitis, Homans,¹⁰ for instance, wrote that "pain early partakes of the nature of a colic—a sustained colic, not an intermittent one"

Persistence of pain despite defecation is not well recognized as an attribute of the pain in the early stage of acute appendicitis. Yet this point is helpful in diagnosis. Persistence of pain despite defecation, despite diarrhea and despite the passing of gas by rectum is one of the most characteristic features of the pain of onset of acute appendicitis.

The patient in case 6 said that he thought that he "was going to have diarrhea." Then he defecated, yet pain persisted despite defecation. Knowledge of this fact aided us in making the diagnosis of acute appendicitis, although diagnosis was otherwise not hard here because pain had localized by the time of the first consultation.

Diarrhea in enteritis may overshadow the pain and the bowel urge (table 1, point 3)

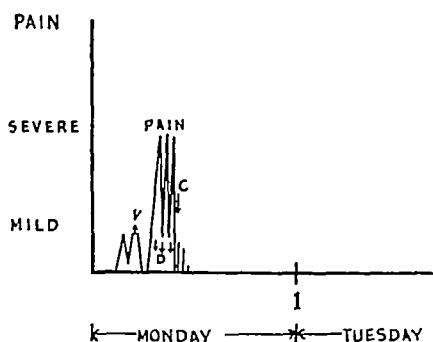


Fig 7 (case 7)—Pain chart in enteritis. *V* indicates vomiting, *D*, diarrhea, and *C*, consultation.

CASE 7—W. A., a youth aged 20, was admitted to the hospital Dec. 11, 1944.

History—The patient said that he awoke suddenly at 4:30 that morning, with a generalized "cramping sensation" accompanied with bowel urge, partially relieved by passing gas. He dozed and then awoke at 7 o'clock and vomited, with "relief for a minute." Then he "had a bowel movement. The first one was normal. That was just like uncorking things, and I spent the next hour on and off the toilet," passing watery stools, each of which "was preceded by considerable pain, in between, I curled up on the davenport and moaned to the boys in the other room (of the fraternity house), and they moaned back to me." His friends had been similarly affected, apparently from eating pumpkin pie with whipped cream at noon and in the evening of the previous day. By the time of the first consultation, seven hours after onset, he said that he "felt all right, except once in a while I get a little cramping."

10 Homans, J. Textbook of Surgery, ed. 5, Springfield, Ill., Charles C. Thomas, Publisher, 1940.

Physical Findings—The patient had a McBurney scar from a previous appendectomy. There was tenderness throughout the abdomen, especially in both lower quadrants of the abdomen. The bowel sounds were hyperactive.

Laboratory Findings—The temperature was 98.4 F and the white blood cell count 17,600, with shift.

Comment—A diagnosis of enteritis due to food poisoning was made. The patient made a prompt recovery. Note how diarrhea dominated the clinical picture.

Diarrhea if present in the early stage of acute appendicitis is subordinate to the painful bowel urge (table 2, point 3)

CASE 8—D. D. C., a 20 year old youth, came to the hospital Jan. 28, 1945.

History—The patient said that he "awoke Sunday morning with the desire to go to the toilet." He passed two liquid stools, with no pain. He said, "That afternoon I again had a desire to go to the toilet, but this time there was quite a bit of pain around the navel, it felt similar to pain when one takes an enema. I had the desire to 'go,' but it felt like something blocking it." He passed another liquid stool and later tried defecation again but unsuccessfully. The pain persisted and was worse when the patient was coughing or walking.

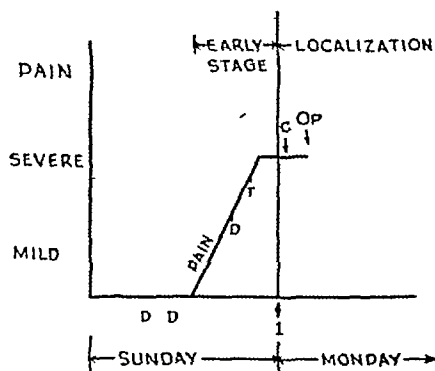


Fig. 8 (case 8)—Pain chart in acute appendicitis. D indicates diarrhea, T, trip to toilet, C, consultation, and Op, operation.

Physical Findings—There was tenderness in the epigastrium and the right lower quadrant of the abdomen, increasing toward McBurney's point. There were muscle guard, rebound tenderness and tenderness by rectum.

Laboratory Findings—The temperature was 99 F, and the white blood cell count was 19,550, with a shift.

Comment—A diagnosis of acute appendicitis was made within twenty-four hours of onset, at first consultation, by criteria in tables 2 and 4. An acutely inflamed appendix was removed, and the diagnosis was confirmed histologically. Recovery was rapid.

Note that, despite diarrhea, pain and bowel urge dominated the clinical picture.

VOMITING

1 In Acute Appendicitis—Vomiting probably occurs less often in acute appendicitis than some authors would lead one to suppose.¹¹

¹¹ Cole, W. H., and Elman, R. *Textbook of General Surgery*, ed. 4, New York, D. Appleton-Century Company, Inc., 1944.

Our figures indicate that nowadays fewer than 50 per cent of patients vomit by the time they are operated on (table 5) The time of vomiting remains to be determined, whether it is relatively commoner during the early stage or during the stage of localization

It seems important that in the early stage the urge to vomit is subordinate to the urge to defecate The order of symptoms also is important Pain always precedes nausea and vomiting in acute appendicitis

2 *In Enteritis*—Quigley and Contratto¹² estimated that about twice as many patients with enteritis vomit compared with the number of patients with acute appendicitis who vomit

TABLE 5—*Incidence of Vomiting in Acute Appendicitis*

Author	Number of Patients Vomited	Total Number of Patients
Spencer, J H, Jr Am J Surg 61 249 1943	57	100
Quigley and Contratto ¹²	23	60
Keyes, E L Unpublished data from Barnes Hospital 1944	10*	24
Totals	90	184

* Seven of these vomited in early stage

Conclusion Fewer than 50 per cent of patients with acute appendicitis vomit by the time they are seen nowadays

MILDNESS OF ONSET OF SYMPTOMS

1 *Acute Appendicitis*.—Eusterman⁵ wrote that "often a vague dyspepsia may precede for some time an acute localizing seizure" of appendicitis Vague or mild onset of this sort was observed in patients 1, 2 and 4 of this series and in many others

Both Reginald Fitz¹³ and John B Murphy¹⁴ called the onset "sudden, severe," while Wilkie¹⁵ called it "very acute and spasmodic at first" Severe onset of this sort was observed in the patient in case 6 of this series, while the initial mild pain of the patient in case 2 became severe just prior to the stage of localization

12 Quigley, T B, and Contratto, A W The Differential Diagnosis of Acute Appendicitis and Acute Gastroenteritis in College Men, New England J Med. 226 787-790 (May 14) 1942

13 Fitz, R H Perforating Inflammation of the Vermiform Appendix, with Special Reference to Its Early Diagnosis and Treatment, Tr A Am. Physicians 1 107-144, 1886

14 Murphy, J B Surgery of the Appendix Vermiformis, in Keen, W W Surgery Its Principles and Practices, Philadelphia, W B Saunders Company, 1908, vol 4, pp 727-796

15 Wilkie, D P D The Etiology of Acute Appendicular Disease, Canad. M A J 22 314-316 (March) 1930

More careful study of the early stage will oftener reveal a mild onset of pain or discomfort, we believe. Ask patients with severe onsets when they last felt perfectly well instead of asking them when they first took sick, and numbers of them will recall mild pain (or "constipated discomfort," as one patient told us) persisting for some hours or days prior to the onset of the acute localizing seizure.

Older authors were inclined to dismiss what we call the early stage as a relatively unimportant, prodromal stage, of little significance. Probably they saw most of their patients in the stage of localization, as we may judge by the advice of McBurney,¹⁶ who in 1889 advised delay in operating as a rule until the fifth day of illness.

2 *Enteritis*—Enteritis began mildly in the patients in cases 3 and 5 of this series. It began in "sudden, explosive" fashion, as described by Quigley and Contratto,¹² in the patient in case 7.

DIARRHEA IN ACUTE APPENDICITIS

The following points have been made in this presentation:

1 Diarrhea makes the differential diagnosis of appendicitis from enteritis difficult.

2 The patient's pain should be analyzed subjectively to determine (a) whether pain is associated with bowel urge or not and (b) how diarrhea affects the pain.

3 Failure thus to analyze symptoms subjectively can delay diagnosis dangerously (case 1).

4 The early stage of appendicitis should be distinguished carefully from the stage of localization, both from the pathologic (Wangensteen⁴ and Wilkie³) and from the chronologic viewpoint.

5 Character and chronology of pain (see charts 1 to 7) should be determined.

The following questions have been raised in the presentation:

1 What effect on pain has diarrhea, defecation and passing gas?

2 Which predominates, the bowel urge or the bowel output?

3 Which predominates, the downward urge to defecate or the upward urge to vomit?

4 What are the answers to questions 1 to 3 in the early stage and in the stage of localization?

NOTE ON CONSTIPATION IN ACUTE APPENDICITIS

First, analyze the patient's "constipated discomfort" from the subjective viewpoint, as suggested. If it is desirable, ask him the following

¹⁶ McBurney, C., in Kelly, H. A., and Hurdon, E. *The Vermiform Appendix and Its Diseases*, Philadelphia, W. B. Saunders Company, 1905.

three questions If the three questions are answered as indicated, acute appendicitis is strongly to be suspected ¹⁷

1 At onset (that is, during the early stage only), did you feel as if something was stopped up inside you? Most patients with acute appendicitis answer, "Yes", some answer, "No"

2 At onset, did you feel as if passing gas or defecating might relieve your discomfort or pain? Patients with acute appendicitis answer this question, "Yes"

3 At onset, if you could pass gas or defecate, did this relieve your discomfort or pain completely? Patients with acute appendicitis answer, "No"

SUMMARY AND CONCLUSIONS

Careful analysis of the early history helps to differentiate acute appendicitis from enteritis, for the physical and the laboratory findings at times may be identical

The character of the early pain differs in the two diseases

In acute appendicitis the early pain persists, often for many hours, sometimes for days

In enteritis, the pain is intermittent Individual pains remit completely after lasting a few minutes only The whole attack rarely lasts over twelve hours

Pain which persists longer than twelve hours should be regarded as indicative of acute appendicitis unless proved otherwise

Pain early in acute appendicitis and in enteritis is associated with bowel urge

Pain during the early stage of acute appendicitis persists despite diarrhea, defecation or passage of gas

Pain in enteritis is completely if temporarily relieved by defecation or by diarrhea.

In early acute appendicitis, the bowel urge exceeds the bowel output In enteritis the reverse may be true

In early acute appendicitis, the downward urge to defecate exceeds the upward urge to vomit

Vomiting is relatively rarer in early acute appendicitis than in enteritis

Our discussion concerns chiefly the early stage of acute appendicitis During the later stage of localization, tenderness increasing near

¹⁷ Keyes ¹ Homans ¹⁰

McBurney's point is commoner in acute appendicitis than in enteritis. Muscle spasm, rebound and rectal tenderness and other signs of peritoneal irritation occur commonly in acute appendicitis and rarely in enteritis.

Diagnosis of acute appendicitis may be made in the early stage by criteria in tables 1 and 2. In differential diagnosis the history is the most important guide, physical and laboratory findings, though less important, are not to be neglected.

TREATMENT OF FRACTURES OF THE CARPAL SCAPHOID

A Report of Sixty-Four Cases

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FRACTURE of the carpal scaphoid is a common finding in military practice. But, unlike fractures of the other bones, the clinical picture usually presents no pronounced objective findings, and unless the examiner tests for local tenderness, restriction of dorsiflexion of the wrist and weakness of the hand the diagnosis is overlooked. Often many months may pass before roentgenograms are taken and the fracture discovered. In fact, in some cases roentgenograms taken in the conventional anteroposterior and lateral views may not disclose the fracture, with the result that the actual pathologic condition is not recognized and is improperly treated.¹ From the standpoint of time lost and persistence of symptoms, the fractured carpal scaphoid must be considered a major disability, comparable in many respects to fractures of the neck of the femur.

The prolonged disability usually associated with fractures of the carpal scaphoid is due chiefly to three factors: first, failure to recognize the fracture soon after the injury; second, inadequate treatment, both as to type of immobilization and as to length of the period of fixation, and, third, disturbance of the circulation in the proximal fragment, with resulting delay in union. Failure to diagnose the condition early is common and has been noted by nearly all writers on this subject. Dickison and Shannon,² stated that the primary problem is early diagnosis and that when seen early and properly treated the fracture will almost invariably unite. In like manner, Soto-Hall and Haldeman³ claimed that early diagnosis is absolutely imperative and failure to institute treatment immediately is one of the main factors in the production of nonunion. Watson-Jones⁴ felt that in every case giving a history of

From the Orthopedic Section, Oliver General Hospital, Augusta, Ga.

1 Murray, G. Bone-Graft for Non-Union of the Carpal Scaphoid, *Brit J Surg* **22** 63 (July) 1934

2 Dickison, J. C., and Shannon, J. G. Fractures of the Carpal Scaphoid in Canadian Army. A Review and Commentary, *Surg, Gynec & Obst* **79** 225 (Sept.) 1944

3 Soto-Hall, R., and Haldeman, K. O. Treatment of Fractures of the Carpal Scaphoid, *J Bone & Joint Surg* **16** 822 (Oct.) 1934

4 Watson-Jones, R. Fractures and Joint Injuries, ed 3, Edinburgh, E & S Livingstone, 1944

injury to the wrist in which tenderness is present over the radial aspect a diagnosis of fracture of the carpal scaphoid bone must be considered unless repeated roentgenograms prove otherwise

The main point in the treatment of fresh fractures is immediate and complete plaster immobilization of the wrist for about three months or until there is evidence of bone healing. When this is carried out, the fractured scaphoid will unite in the vast majority of cases. The failures result because of a lack of appreciation by many physicians of the importance of immediate and prolonged immobilization. The question is frequently asked: Why is it necessary to immobilize the wrist for several months in fractures of the scaphoid when only three weeks suffice for fractures of the bones of the hand and the forearm? The length of the period of fixation is dependent on the time it takes for the bone to heal. Bones of the cancellous type heal more slowly than long bones, and in the cases of fracture across the waist or proximal pole of the scaphoid bone union is further delayed by the intra-articular nature of the fracture and, in about one third of the cases, by a disturbance of the circulation to the proximal fragment.

Fractures of the scaphoid may occur at three different levels: at the tubercle, at the waist and at the proximal pole. Fractures of the tubercle occur in only a small percentage of cases. The fracture is extra-articular, there are strong ligamentous attachments to it, and the blood supply is ample. Bony union takes place early, and the wrist is immobilized for a period of only three weeks. Fractures across the waist, or constricted midportion, of the bone are the commonest. As in fractures of the proximal pole, they are intra-articular, they heal slowly, and in an appreciable percentage of cases there is an impairment of the blood supply to the proximal fragment. Firm, uninterrupted plaster immobilization is essential for a period of three months or longer, until there is a disappearance of the fracture line as seen by roentgenologic examination.

Dickson and Shannon,² in a review of 257 cases of fractured carpal scaphoids, found the tubercle involved in 23 cases, or in 10 per cent, the waist in 196 cases, or 75 per cent, and the proximal pole in 38 cases, or 15 per cent. The average period of immobilization in their 114 cases of fractures of the waist which united was twelve and one-half weeks. In only 10 per cent was there evidence of healing at the end of two months, in 48 per cent, the bone healed in three months, in 74 per cent in four months and in 82 per cent in five months.

Obletz and Halbstern,⁵ in a study of the blood supply of two hundred and ninety-seven carpal scaphoids which had been removed from cadavers, found that in 13 per cent of the bones there were no arterial for-

5 Obletz, B. E., and Halbstern, B. M. Non-Union of Fractures of the Carpal Navicular, *J. Bone & Joint Surg.* 20: 424 (April) 1938.

mens proximal to the waist and in 20 per cent there was a single small arterial foramen at the waist or proximal to it. Since most fractures occur in this region, the circulation of the bone proximal to it would be completely interrupted in 13 per cent of the cases and impaired in another 20 per cent. Thus in about one third of the cases a disturbance in the blood supply of the proximal fragment occurs, which delays union and if not properly treated will result in nonunion. Johnson,⁶ in a study of the healing processes in injuries of the carpal scaphoid in dogs, found a lack of periosteal callus a large factor in delay of bony union.

It is now well recognized that in fractures across the waist and the proximal pole of the scaphoid union is delayed and immobilization must be maintained until bone healing is noted by roentgenologic examination. Nonunion usually results when the fracture is not recognized early and when immobilization is not complete or is not maintained for a long enough period. Thorndike and Garrey⁷ reported that of 17 cases observed in a college clinic 11 cases, or 65 per cent, were those of old, previously unrecognized fractures of the scaphoid. Oblatz and Halbstern,⁸ in a review of 30 cases of nonunion, found that in 17 the fracture was not recognized and in the others the treatments given were inadequate. Henry⁸ found an incidence of 25 per cent of nonunion in a series of 12 cases seen in an industrial practice and in 32 per cent of 22 cases seen in a large receiving and embarkation base.

There can be little doubt that the high incidence of nonunion with resulting long disability is in large measure a reflection of the type and the character of medical service rendered. It is, therefore, in the hope of improving the understanding and treatment of this fracture that this paper is presented.

MAIN FACTORS IN THE MANAGEMENT OF THE FRACTURED SCAPHOID

1 Early Diagnosis—A thorough clinical examination of the wrist should be made in all cases. Restriction of motion, especially of dorsiflexion, localized tenderness and weakness of the hand, are to be noted. Roentgenograms are to be taken in all cases in which there is a history of injury and in all others in which symptoms persist and no improvement has occurred after a week to ten days of treatment. When one considers the large number of fractures that have been missed because roentgenograms were not taken, it seems imperative to adopt a policy of roentgenologically examining all patients giving a history of a fall on the outstretched hand or any other injury to the wrist joint. The roentgeno-

6 Johnson, R. W., Jr. A Study of the Healing Processes in Injuries to the Carpal Scaphoid, *J. Bone & Joint Surg.* **9** 482 (July) 1927.

7 Thorndike, A., Jr., and Garrey, W. E. Fractures of the Carpal Scaphoid, *New England J. Med.* **222** 827 (May 16) 1940.

8 Henry, M. G. The Fractured Carpal Scaphoid in Industry and in the Military Service, *Mil. Surgeon* **95** 199 (Sept.) 1944.

grams should be taken in three views anteroposterior, lateral and oblique. For the anteroposterior view, it is necessary to hold the hand in ulnar deviation to get a complete view of the scaphoid. In some cases the fracture may not be seen on a roentgenogram, however, if symptoms persist new roentgenograms are to be taken at the end of two to three weeks.

2 Closed Reduction of Fracture and Complete Immobilization in a Plaster of Paris Cast—The fracture should be reduced with the patient under anesthesia if any displacement or separation of the fragment is present. The cast should extend from just below the elbow to the interphalangeal joint of the thumb and to the metacarpophalangeal joints of the other fingers. The wrist should be maintained in moderate dorsiflexion and radial deviation and the thumb in slight abduction. This position will fix the scaphoid and thumb and yet provide ample and complete freedom of movement of the other fingers. Check-up roentgenograms should be taken at monthly intervals, and at the end of three months the cast is bivalved and roentgenograms taken while the position of the wrist is held. If insufficient healing of the bone is noted, a new cast is applied and left on for another month. Usually three months of immobilization is sufficient time to allow for union to take place. In cases in which no signs of bone healing can be discerned after three to four months of fixation—and this may occur in fractures across the waist and the proximal third of the bone—operation is indicated.

3 Open Operation—In fresh fractures, operation should be performed only when the scaphoid is badly comminuted, with the fragments displaced, and when attempts at closed reduction have failed. Operation in this instance is resorted to in order to prevent the development of a painful traumatic arthritis of the wrist. The vast majority of patients that come to operation are those with ununited fractures that have been overlooked and treated for months as mild sprains or when seen early were inadequately immobilized and treated by strapping and physical therapy. In these cases further conservative therapy would offer little hope of obtaining bony union. The main criterion for operation is non-union associated with persistence of clinical symptoms and with the patient unable to perform his regular duties. Every patient considered for operation must be carefully scrutinized so as to eliminate the psychoneurotic patients and those harboring a desire to avoid duty. The temptation to play sick is inviting to some and unless this is guarded against the best operation may result in clinical failure.

There are many operative procedures that have been used. The commoner ones are the following: total and partial excision of the scaphoid, drilling of the bone and bone graft.

The total excision of the scaphoid has been advocated by some surgeons. Davidson and Horwitz⁹ recommended the operation in all badly comminuted fractures of the scaphoid and in some cases of non-union with persistent disability that have been given a fair trial of conservative therapy. Henry,⁸ in a recent paper, advised the complete excision of the bone in fractures through the middle and inner third when there is any degree of displacement. Most surgeons, however, would disagree with this view. The main objection to the operation is that it tends to disorganize the general alignment and architecture of the carpal bones. In my experience, this operation should be employed only in pronounced comminuted fractures of the scaphoid in order to prevent the development of traumatic arthritis of the wrist.

Partial excision of the small, ununited proximal fragment is indicated in cases in which the fracture is across the proximal third of the bone and when it is displaced or separated and is small. This procedure is also used when the proximal fragment has undergone avascular necrosis, as noted on the roentgenogram by the increased density of the bone. In other cases, the operation may be employed when symptoms persist with no evidence of bony union after a period of three to four months of plaster immobilization and when the proximal fragment is too small for drilling or for the insertion of a bone peg. After the excision of the small proximal fragment, the general position and alignment of the carpal bones are not disturbed. Motion of the wrist is started shortly after the operation. In selective cases the operation is of distinct value. This paper will present the case histories of patients on whom the operation has been performed.

Drilling of the fractured bone is advocated by many surgeons for nonunion. According to Obletz and Halbstem,⁵ drilling, when followed by adequate immobilization, is the treatment of choice for ununited fractures of the carpal scaphoid. Soto-Hall and Haldeman³ advised this procedure, and Rothberg¹⁰ felt that firm bone union may be expected from this simple method. Bunnell¹¹ found that drilling often succeeds in restoration of circulation and leads to union. Watson-Jones⁴ stated that in the treatment of fractures of the carpal scaphoid with established nonunion immobilization alone will not succeed and that it must be preceded by either multiple drilling or bone grafting to obtain union. In my opinion, drilling is of value in cases in which the fractured fragments

9 Davidson, A. J., and Horwitz, M. T. An Evaluation of Excision in the Treatment of Ununited Fracture of the Carpal Scaphoid Bone, *Ann Surg* **108** 291 (Aug.) 1938

10 Rothberg, A. S. Ununited Fractures of the Carpal Scaphoid, *Am J Surg* **56** 611 (June) 1942

11 Bunnell, S. *Surgery of the Hand Philadelphia* I. B. Lippincott Company 1944

are in apposition and there is no displacement or bone absorption of the fragments. The operation is simple, is easily carried out and when followed by adequate immobilization will often result in bone union. The main purpose of drilling is to break across the sclerosed bone at the fractured ends and permit the ingrowth of vascular channels into the proximal fragment, with resultant healing of the fracture.

The bone graft operation is indicated in cases of nonunion associated with symptoms and prolonged disability. I have used an autogenous tibial bone peg, with satisfactory results. The graft has the added advantage over drilling in that it insures bony continuity by internal fixation of the fragments and provides a local store of calcium on which the body may draw. The operation offers the best means of obtaining union in old, ununited fractures. Although some physicians are opposed to the bone graft because it is a highly technical procedure, the operation is not difficult, but it should be attempted only by a surgeon who is familiar with the use of a motor saw. Check-up roentgenograms should be taken during the operation to make sure that the graft is in the exact position.

The operation consists in removing a small graft from the tibia and converting it into a rounded peg. This is then inserted into a previously prepared drill hole across the fracture line in the scaphoid. The size of the bone peg should correspond to the hole and should fit snugly so as to obtain firm internal fixation of the fragments. I use the Albee bone mill¹². The wrist is then immobilized in a plaster cast in moderate dorsiflexion and radial deviation, and the cast should extend from the upper third of the forearm to the interphalangeal joint of the thumb and to the metacarpophalangeal joints of the other fingers. The plaster is left on for three months or until there is evidence of bone healing on roentgenologic examination.

CLINICAL DATA

From January 1943 to April 1945, 64 patients with fracture of the carpal scaphoid were admitted to the Oliver General Hospital. The patients came from station hospitals serving nearby training camps and from hospitals overseas. The average age was 26, the youngest patient was 19 and the oldest 37 years. In this series, only 39 patients, or 61 per cent, received adequate plaster immobilization of the wrist shortly after the injury. In 3 cases a splint was applied and left on for three to six weeks, while in 5 others the wrist was strapped with adhesive tape or was given physical therapy. Seventeen patients received no immediate treatment, their fractures were overlooked and diagnoses were not made until months or years later.

¹² Albee, F. H., and Kushner, A. *Bone Graft Surgery in Disease, Injury, and Deformity*, New York, D. Appleton-Century Company, Inc., 1940.

Of the 39 patients receiving proper immobilization, the fracture united in 34, or 87 per cent. The average length of fixation was three months. In 5 patients nonunion developed and required open operation. In 2 of these the small proximal fragments were excised, and in 1 the fragments were drilled, in 2 cases bone grafts were used. Of the 25 patients not receiving adequate immediate fixation, nonunion developed in 24, or 96 per cent (table 1).

From the figures given, it is apparent that early, complete and prolonged plaster immobilization of the fresh fractured carpal scaphoid is most important and is the key to the successful treatment of this fracture. Fixation should be maintained until there is distinct evidence of union by roentgenologic examination as seen by the disappearance of the fracture line and uniform density of the bone structure.

Nonunion was found in 29, or 45.3 per cent of the cases. Twenty patients were operated on, 17 by me and 3 by others at different hospitals. Nine patients received no specific treatment. Of the latter, 3

TABLE 1—*Analysis of Sixty-Four Cases*

	Cases		Cases of Bony Union		Cases of Nonunion	
	No	%	No	%	No	%
Plaster immobilization after injury, 2 to 4 months	39	61	34	87	5	13
Splint, 3 to 6 weeks	3	4.7	1	33	2	66
Adhesive strapping or physical therapy	5	7.8	0	0	5	100
No immediate treatment fracture not diagnosed until 3 months later	17	26.5	0	0	17	100
Total	64	100	35	54.7	29	45.3

patients sustained this injury prior to induction into the service, 1 having received it sixteen years ago. The symptoms and restriction of wrist motion were mild. In 2 patients the fractured scaphoid was first discovered during a routine general physical examination. They had no recollection of any injury to the wrist. Roentgenograms disclosed old nonunion of the carpal scaphoid. There were no symptoms and only mild objective findings. Both patients were in the hospital on account of other injuries. In 1 case because of the presence of a duodenal ulcer and in another because of psychoneurosis, operation was not deemed advisable. One patient was transferred to another hospital and later returned to duty. Of the 9 patients in the nonoperative cases, 1 was returned to full general duty, 1 was discharged from the service on account of renal glycosuria and 7 were reclassified to limited duty.

In the operative group, the procedures employed were excision of the proximal fragment, drilling of the bone and bone graft. Of the 3 patients operated on elsewhere, drilling was employed in 1 and bone grafts in 2. Of the 17 patients operated on here, excision was per-

formed in 6, drilling in 3 and bone grafts in 10. Two of the latter were later reoperated on and the proximal fragment excised. The average period from date of injury to operation was fourteen months.

REPORT OF CASES

Partial Excision of the Carpal Scaphoid Bone—The first 6 cases are typical of this group.

CASE 1—The patient, aged 25, injured his wrist in February 1943, when he fell on an extended arm bending his wrist backward. The condition was con-

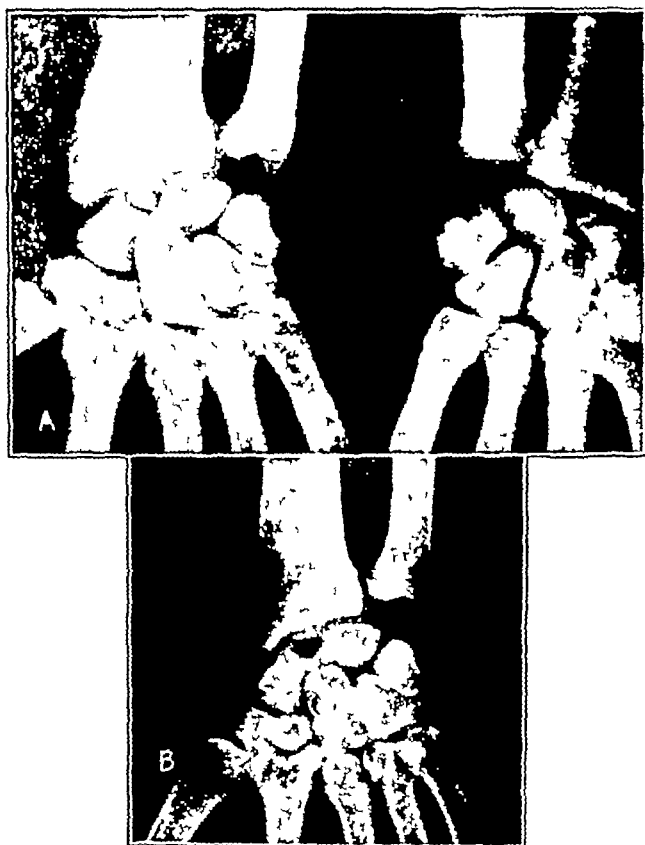


Fig 1 (case 1)—*A*, roentgenogram taken twenty-two months after injury, showing nonunion fracture of the proximal pole of the scaphoid. *B*, ten days after excision of the small proximal fragment. The general alignment of the proximal carpal bones has not been disturbed.

sidered a sprain, and when the symptoms subsided he was sent overseas with his outfit. Three months after his arrival because of pain and stiffness in dorsiflexion, the first roentgenograms were taken which revealed a fracture of the carpal scaphoid. A cast was applied and left on for two months, without any improvement.

On examination, there were localized tenderness and pain on dorsiflexion of the wrist. Roentgenograms revealed a fracture of the proximal pole of the

scaphoid (fig 1A) On Dec 4, 1944, twenty-two months after his injury, an operation was performed and a small, loose, triangular fragment excised. The fractured end was found to be smooth and loosely connected by fibrous tissue. Microscopic section disclosed avascular necrosis of the bone. Roentgenograms taken on December 14 showed the small fragment removed and the general position and alignment of the proximal carpal bones unchanged and in normal relationship to the radius (fig 1B).

CASE 2—The patient, aged 31, injured his wrist on Sept 5, 1944, when thrown approximately 30 feet (9.1 meters) as a result of a nearby shell explosion. He did not apply for treatment until two months later, when roentgenograms were taken and a fracture of the scaphoid disclosed. A plaster cast was then applied and left on for four months, but without relief of the symptoms.

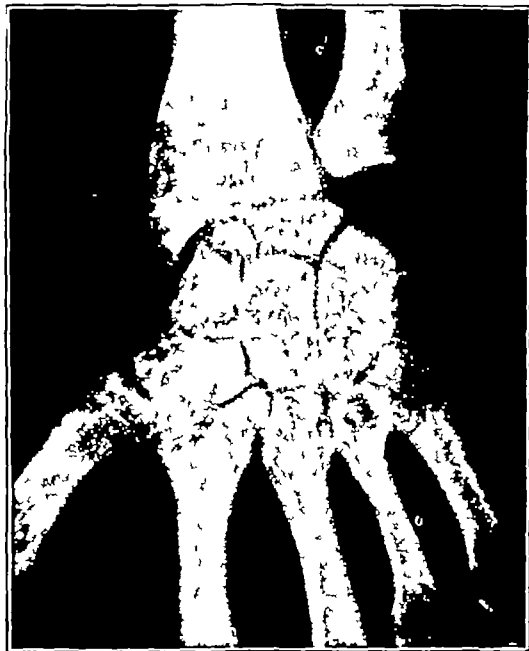


Fig 2 (case 2)—Roentgenogram taken April 2, 1945, seven months after injury, showing nonunion fracture across the proximal pole. The small fragment is slightly displaced and presents a dense appearance indicative of avascular necrosis of the bone.

On examination, motion of the wrist was moderately restricted and painful, especially in dorsiflexion. There was tenderness over the carpal scaphoid. Roentgenograms taken April 2 disclosed an old fracture of the proximal pole of the scaphoid with nonunion. The upper fragment was slightly displaced and appeared denser than the rest of the bone (fig 2). On April 5 the proximal fragment was excised and early motion started.

CASE 3—The patient, aged 33, injured his left wrist in September 1943, when his truck collided with another car, as a result of which he sustained a fracture of the semilunar and scaphoid bones. The wrist was immobilized in a number of plaster casts for about six and one-half months and the patient was then returned

to duty. In December 1944, because of complaints of pain and stiffness in the wrist, he was admitted to another hospital, and after receiving physical therapy he was sent back to duty. However, two weeks later he was readmitted and then transferred to this hospital for treatment.

On examination, all motion of the wrist was restricted and painful. There was tenderness over the scaphoid. Roentgenograms disclosed an old fracture of the proximal pole of the scaphoid with several ununited, loose fragments and with evidence of early traumatic arthritis (fig 3A). On April 12 he was operated on, and three small, irregular, bony fragments, loosely attached to the scaphoid, were excised (fig 3B). On the next day, active motion was started and the patient was instructed to move the wrist.

In the following case, avascular necrosis of the proximal fragment developed as a result of severe injury to the wrist.

CASE 4—The patient, aged 21, sustained an injury to his left wrist when he was thrown from a jeep. Roentgenograms were immediately taken which dis-



Fig 3 (case 3)—A, roentgenogram taken March 3, 1945, showing an old fracture of the proximal pole of the scaphoid. The upper fragment is irregular and has a dense appearance. At operation three small, loose, dense fragments were found in this area and were removed. The wrist joint is narrowed, and there is some sclerosis of the articulating surface of the radius indicative of early traumatic arthritis. B, postoperative view. The loose fragments were completely excised.

closed a fracture of the lower end of the left radius and ulna, a fracture of the scaphoid and a dislocation of the semilunar bone. An attempt was made at the station hospital to reduce the fractures, but only the dislocated bone was replaced and the patient was transferred to this hospital for further treatment (fig 4A).

On examination, motion of the wrist was restricted and painful. There were moderate swelling and tenderness of the wrist joint. With the patient under general anesthesia, the fractured scaphoid was reduced (fig 4B) and a plaster cast applied. Five weeks later, roentgenograms were taken which disclosed the proximal fragment dense and sclerotic, indicative of avascular necrosis of the bone (fig 4C). In view of this finding, the proximal fragment was excised (fig 4D). The pathologic report was avascular necrosis of the bone.

CASE 5—The patient, aged 28, injured his left wrist on June 3, 1943, when his hand was caught between a gun and the side of a tank. His condition was treated as a sprain. However, because of continued symptoms, roentgenograms were taken, which disclosed a fracture of the proximal pole of the scaphoid (fig 5A)

On examination, motion of the wrist was restricted and painful, particularly in dorsiflexion. Tenderness was localized over the scaphoid bone. Because of

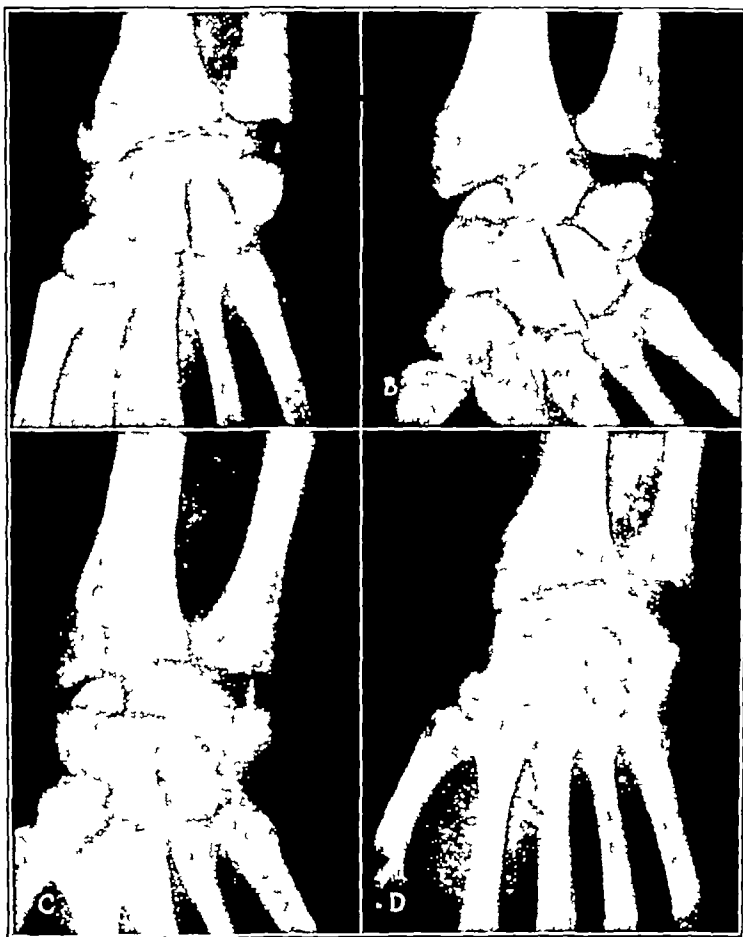


Fig 4 (case 4)—A, roentgenogram taken eleven days after injury, showing fracture across the proximal pole with dislocation of the upper fragment. There is also a fracture of the lower outer end of the radius and a fracture of the styloid process of the ulna. B, reduction of the fractured scaphoid. C, on October 16, seven weeks after the injury, the proximal fragment is dense and sclerotic, indicative of avascular necrosis of the bone. D, the proximal fragment excised and motion started.

the persistence of symptoms and disability with the presence of nonunion, a bone peg was inserted. The wrist was immobilized for four months, and then physical therapy was started. However, the patient still complained of pain

Roentgenograms showed the bone peg extending beyond the articular surface of the bone, with no evidence of union. The proximal fragment was therefore excised (fig 5B).

CASE 6—The patient, aged 29, injured his right wrist in July 1942, when he fell off a truck. It was considered a sprain, and after a week of rest he returned to duty. In June 1944 he again injured his wrist, and roentgenograms disclosed a fracture of the scaphoid. A cast was applied and left on for a month. He was then returned to duty but was unable to continue his work.

On examination, there were tenderness and moderate restriction of motion of the wrist. Roentgenograms disclosed an old, ununited fracture of the scaphoid. On Dec 5, 1944 a bone peg was inserted, and check-up roentgenograms revealed satisfactory position. There was no postoperative reaction, and two weeks later the patient was given a furlough. While home, he became intoxicated and removed the cast. When he returned, he had on a loose, short cast, which had been



Fig 5 (case 5)—A, roentgenogram showing old fracture across the proximal pole of the scaphoid. B, after excision of the small proximal fragment.

applied the day before at a dispensary. Roentgenograms disclosed the bone peg displaced in the joint. An excision of the proximal fragment was performed and active motion started.

Drilling Operation—The following case is typical of the group.

CASE 7—A private, aged 29, while finishing his training in Northern Ireland, fell on his outstretched hand and injured the right wrist. Two days later, roentgenograms were taken which revealed a fracture of the scaphoid. His wrist was not immobilized, and shortly thereafter he was sent with his outfit to France. While in action, he received a rifle bullet injury, sustaining a compound comminuted fracture of the upper third of the ulna. When seen here, his chief complaint was pain and stiffness of the right wrist.

On examination, motion of the wrist was considerably restricted in volar flexion and dorsiflexion. Side bending gave rise to pain, and there was tender-

ness over the scaphoid. The fractured ulna was firmly united. Roentgenograms disclosed nonunion of the scaphoid and a healed comminuted fracture of the ulna. Because of the persistence of symptoms a bone peg procedure was considered, but at operation eight months after the injury the fractured scaphoid bone was found to be in excellent position and in close contact and drilling was done instead. As the drill passed across the fractured ends of the bone an increase in resistance was felt.

Bone Graft Operation—Typical of this group are the following cases.

CASE 10—A private first class, aged 24, injured his wrist in January 1943, when he fell on the ice while running to catch a bus. He had another injury



Fig. 6 (case 10)—Roentgenogram showing old fracture across the waist of the scaphoid. The fracture ends appear rounded and show cystic changes.

on Dec. 3, 1943, when he fell backward, landing on his right hand. Roentgenograms were taken which disclosed a fracture of the carpal scaphoid.

On examination, motion of the wrist was considerably restricted. There was tenderness over the scaphoid and weakness of the hand. Roentgenograms disclosed a transverse fracture through the scaphoid, with slight separation of the fragments. The fracture edges were rounded and showed cystic changes (fig. 6). On Jan. 16, 1944, twelve months after the original injury, a tibial bone peg was inserted. The wrist was immobilized in a plaster cast for three months, and an aluminum cock-up splint was then applied and left on for another month. Physical therapy was begun after the removal of the casts. Roentgenograms showed the bone graft in place (fig. 7). The postoperative course was uneventful, and the patient was discharged to full duty.

CASE 11—A corporal, aged 24, injured his right hand in July 1943 as a result of recoil from a gun breech while he was stationed in Panama. He had pain and swelling of the wrist, but at the time of injury he was stationed in the jungle and had no medical treatment. Three months later he was examined



Fig 7 (case 10)—Four months after operation. The bone graft is in place and the fracture line indistinct.

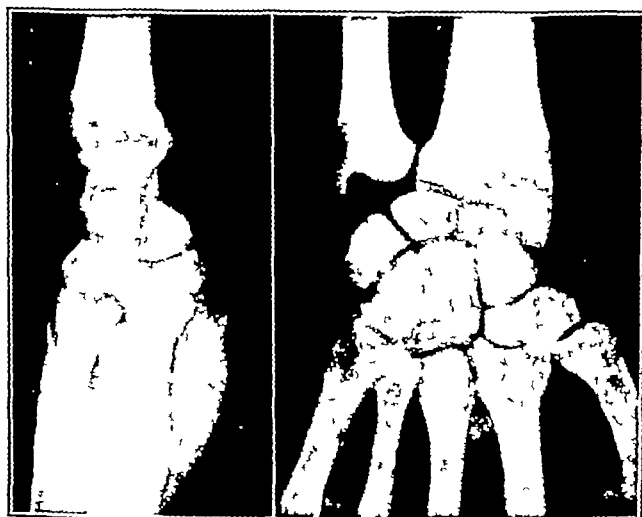


Fig 8 (case 11)—Roentgenograms taken March 24, 1944, eight and a half months after the injury, shows fracture across the proximal pole of the scaphoid. The fracture line is distinct.

by a medical officer, but no roentgenograms were taken. Because of persistent pain in the wrist and weakness of the hand, he was admitted to the station hospital, where roentgenograms were taken which disclosed a fracture of the scaphoid (fig 8).

On examination, there were localized tenderness and weakness of the grip of the right hand. A tibial bone peg operation was performed on April 25, 1944, ten months after the injury. At operation the bone fragments were movable on slight pressure. Roentgenograms taken show the bone peg in place (fig 9 *A*). On July 21 the cast was removed, and roentgenograms taken disclosed that the fracture line was indistinct and union was present (fig 9 *B*). Physical therapy was started, and all motions of the wrist returned to normal. He made a complete recovery and was returned to full duty.

CASE 16—The patient, aged 29, injured his hand during a parachute jump in October 1942. A plaster cast was applied and left on for five months, and the patient was then returned to duty. In September 1944 he again injured his

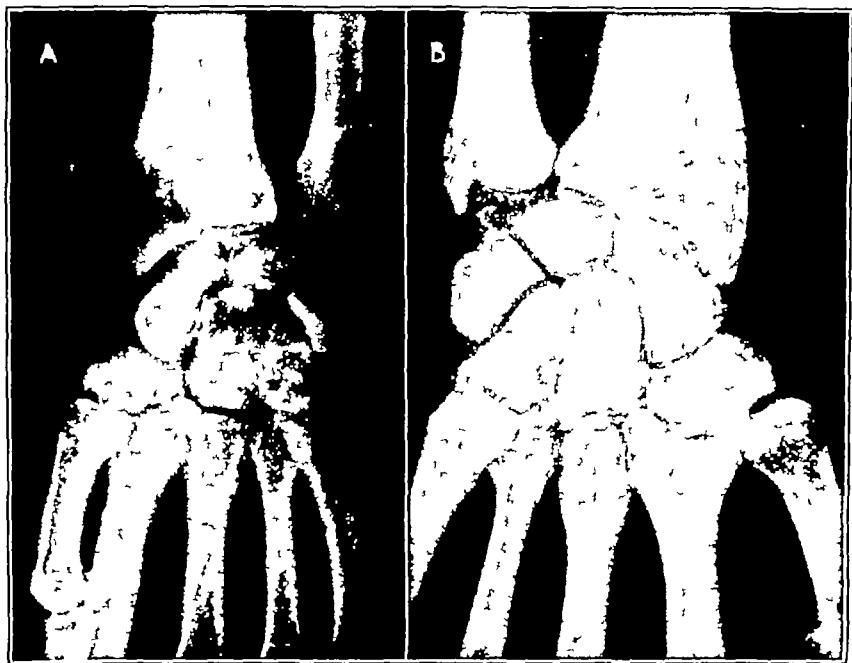


Fig 9 (case 11) —*A*, the bone peg is in place. *B*, on July 25, 1944, three months following operation, there is firm bony union of fracture. The fracture line is not seen.

wrist. Roentgenologic examination disclosed nonunion of the carpal scaphoid and a fresh fracture of the styloid process of the ulna.

On examination, there was restriction of motion of the wrist and tenderness over the scaphoid. A roentgenogram taken February 10 disclosed an old, ununited fracture across the waist of the scaphoid. There was a small fragment lateral to the main fracture line (fig 10 *A*). On March 13 a tibial bone peg was inserted and a cast applied (fig 10 *B*).

CASE 17—The patient, aged 35, injured his right wrist while in action on July 13, 1944. The wrist was fixed in plaster for about five months. However, he still complained of pain and stiffness and was therefore evacuated to the Zone of the Interior.

On examination, motion of the wrist was greatly restricted. There was tenderness over the scaphoid. Roentgenologic examination disclosed an old fracture of the scaphoid with nonunion (fig 11A). On April 2 a tibial bone peg operation was performed and a cast was applied (fig 11B).



Fig 10 (case 16) — *A*, roentgenogram taken Feb 10 1945 twenty-nine months after the first injury, discloses an old, ununited fracture across the waist of the scaphoid. There is an increased density of the fractured ends, with a healed small fragment lateral to the main fracture. *B*, bone peg in place and extending across the fracture line. The position and alignment of the bone are good. The plaster cast is applied in slight radial deviation and extends to the interphalangeal joint of the thumb and to the metacarpophalangeal joints of the other fingers.

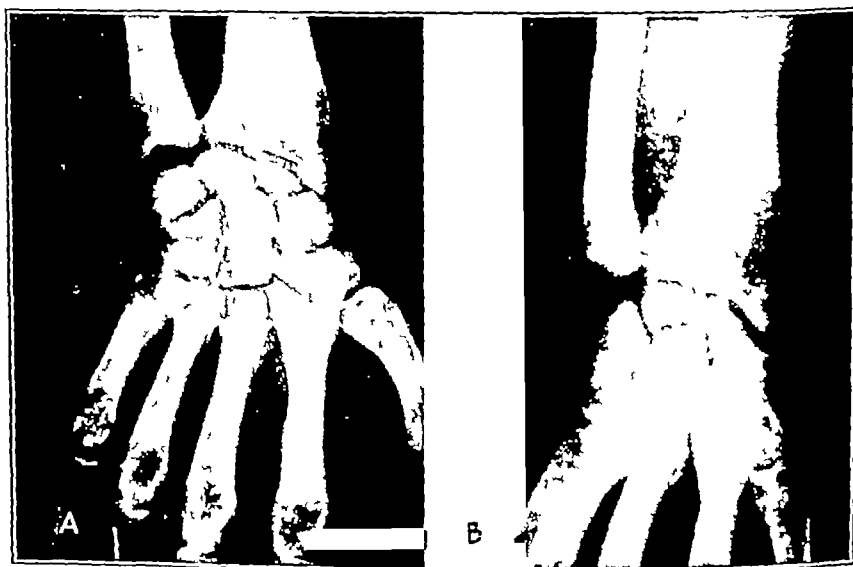


Fig 11 (case 17) — *A*, roentgenogram taken Jan 9, 1945, six months after the injury, discloses an old fracture across the scaphoid, with nonunion. There is slight separation of the fragments. *B*, bone peg in place. Position and alignment of the fragments are good.

COMMENT

Although the number of operative cases is not large, the clinical picture is typical of the general pattern of this fracture. A common finding in the case histories is the failure to diagnose the condition early and to immobilize the wrist adequately. In many cases the condition was considered a mild sprain, and, after the wrist had been strapped with adhesive tape, the patient was returned to duty. As a consequence, nonunion developed, with resulting pain and stiffness. What at first is a simple fracture when improperly managed may result in an incapacitating disability which may require many months to resolve. It is obviously imperative for the physician to become cognizant of this condition, to recognize the pathologic condition early and to firmly immobilize the wrist for about three months if he is to avoid undesirable sequelae.

The presence of nonunion of the scaphoid is not in itself an indication for operation. In 2 of the patients the fracture was accidentally discovered in the course of a routine examination. They had no symptoms and no recollection of any injury to the wrist. The patients were in the hospital on account of other injuries. In several other cases the symptoms and restriction of motion were mild, and the condition had existed for many years without much discomfort. Operation, however, is indicated when symptoms and disability are associated with the nonunion and when the patient is unable to continue with his regular duties.

In such cases I have employed three types of operative procedure. The choice depends on the type, the position and degree of separation and the displacement of the fractures. Excision of the proximal pole is especially indicated when the fragment is small or displaced or when avascular necrosis develops. Drilling across the fractured fragments is of value in cases of nonunion when the fragments are in close contact and in good alignment. The operation is simple and is easily carried out. The bone graft operation should be employed in cases of nonunion across the waist and in cases in which there is separation or displacement of the fragments. The graft provides firm internal fixation of the fractured bone. At first, a large bone peg (Albee peg 2) was used, measuring 238 inches (0.5 cm), now the small peg (peg 1), 145 inches (0.3 cm), is mainly used and provides firm fixation with the least destruction of bone substance.

Firm immobilization with plaster is essential following drilling and bone graft operations. This is maintained for about three months or until there is evidence of union by roentgenologic examination. After partial excision of the bone active motion is started twenty-four to forty-eight hours after operation and in a month the patient is able to return to duty.

There were no postoperative reactions in these cases, and in a few days after operation the patients were up and about. Patients with plaster casts are advised to exercise their fingers, and all the patients are urged to go to the occupational therapy department, where they are assigned to special projects to facilitate movement of the finger joints. One of the patients was a weaver, and with the cast on he was able to make rugs and teach others how to work on the loom. In civilian practice, this group of patients could be discharged from the hospital in a few days after operation and would be able to do light work until the casts were removed.

In selection of patients for operation, an attempt should be made to rule out patients showing psychoneurotic traits or harboring a desire to avoid going back to duty. Unless this is done, the best operative result may often prove unavailing and not alleviate the patient's complaints. The military patient has the advantage over the civilian patient in that he continues to draw his full pay and enjoys all the rights and privileges associated with his rank. Life in a hospital is pleasant and comfortable as compared with life in the field. The hazards and the dangers of battle conditions are so vividly remembered by some patients that their desire to avoid another such experience may hamper and delay their complete recovery. In 3 patients operated on at other hospitals the roentgenograms revealed complete bony union of the fractured scaphoid, and on examination there was only slight limitation of motion of the wrist. Yet, despite the evident good result, they still complained of pain and were referred to this hospital for further treatment. After a short stay here, they were returned to full duty.

In 1 of my own patients (case 13), a bone graft operation was performed, and after the plaster was removed he was referred to a convalescent hospital prior to his return to duty. While at that hospital he continued to complain of pain and stiffness in the wrist and, as a result, was sent back to me for further treatment. Roentgenograms taken disclosed complete and firm bony union of the fractured scaphoid. Because of the restriction of motion of the wrist, he was taken to the operating room and, with the patient under general anesthesia, the wrist was manipulated. The range of motion was good, with only a slight limitation in dorsiflexion and volar flexion. His symptoms were considered largely functional. He was encouraged to move his wrist constantly, and after a short stay he returned to limited duty.

Because of the presence of associated injuries, diseases or psychogenic factors, the final result cannot be measured entirely by the disposition of the case but, rather, must be determined by roentgenologic examination, by objective findings, such as range of motion of the wrist, swelling, tenderness and weakness of the grip, and by the subjective

complaints In the cases of partial excision of the bone, the results in 3 (cases 1, 2 and 4) must be regarded at good, in 1 (case 3) as undetermined, as the patient is still under treatment, and in 2 (cases 5 and 6) as fair (table 2) In the last group, 1 patient returned to full duty, but in a follow-up letter a year later he still complained of pain, the other patient was given limited duty and assigned to this hospital In case 3, the roentgenograms disclosed a healed fracture of the semilunar and a fracture of the proximal pole of the scaphoid, with three small ununited bone fragments and with evidence of traumatic arthritis of

TABLE 2—Analysis of Seventeen Operative Cases

Case	Age of Patient, Yr	Date of Injury	Immediate Treatment	Operation	Date of Operation	Period Injury to Operation, Mo	Clinical Result		
							Union Shown by Roent gram*	Objective Find ings	Subjective Find ings
1	25	2/43	Strapping	Excision	12/ 4/44	22		Good	Good
2	31	9/5/44	None	Excision	4/ 5/45	7		Good	Good
3	33	9/43	Plaster cast	Excision	4/13/45	19		Fair	Poor
4	21	8/30/44	Plaster cast	Excision	10/18/44	7 weeks		Good	Good
5	28	6/ 3/43	Strapping	Bone graft Excision	2/17/44 7/ 6/44	8½	—	Good	Fair
6	29	7/43	None	Bone graft Excision	12/ 8/44 3/ 5/45	25	—	Fair	Good
7	29	1/44	None	Drilling	2/ 6/45	8	++	Good	Good
8	23	9/44	Splint	Drilling	4/19/45	7	++	Good	Good
9	31	12/44	None	Drilling	4/20/45	5	Undetermined, patient under treatment		
10	24	1/45	None	Bone graft	1/27/44	12	+	Good	Good
11	23	2/20/43	Strapping	Bone graft	2/29/44	12	+	Good	Good
12	24	7/43	None	Bone graft	4/25/44	9	++	Good	Good
13	27	5/5/43	Splint	Bone graft	6/ 1/44	13	++	Good	Fair
14	27	11/41	None	Bone graft	6/30/44	31	+	Good	Good
15	33	10/43	Splint	Bone graft	7/ 3/44	21	+	Fair	Fair
16	29	10/42	Plaster cast	Bone graft	3/13/45	30	Undetermined patient under treatment		
17	35	7/13/44	Plaster cast	Bone graft	4/ 2/45	9	Undetermined patient under treatment		

* Explanation of symbols ++ = firm bony union with disappearance of fracture line + = union, with fracture line and bone graft still visible and — = no union

the wrist joint Fusion of the wrist was considered but excision of the loose fragments was performed in the hope that by removal of the irritant factors the arthritic symptoms would clear up The result in this case must be considered undetermined and possibly poor

Of the 3 patients that had drilling operations, the results in 2 cases (cases 7 and 8) are good and in 1 uncertain In the latter, the patient was only recently operated on In the series of bone grafts, the results in 4 cases (cases 10, 11, 12 and 14) are good and the patients were returned to full duty In 2 (cases 13 and 15), the results are fair, objectively they are good, but subjectively the patients continued to

complain of pain. They were returned to limited duty. Two patients (cases 16 and 17) are still in the hospital, and the postoperative roentgenograms (fig 8B and 9B) show the graft in place and in good position.

SUMMARY

1 Fracture of the carpal scaphoid bone is a common finding in military practice. From the standpoint of time lost, persistence of symptoms and disability, the fractured carpal scaphoid bone is comparable in many respects to fractures of the neck of the femur.

2 The prolonged disability frequently associated with fractures of the scaphoid is due to three main factors: first, failure to recognize the fracture soon after injury, second, inadequate treatment, both as to type of immobilization and as to period of fixation, and, third, disturbance of the circulation to the proximal fragment, with resulting delay in union.

3 Early diagnosis is most important. Roentgenograms are to be taken in all cases in which there is a history of a fall on the outstretched hand or any other injury to the wrist and in all others in which symptoms persist and no improvement has occurred after ten days of treatment. Roentgenograms should be taken in three views: anteroposterior, lateral and oblique. In some cases, the fracture may not be seen on roentgenologic examination, however, if symptoms persist, new roentgenograms are to be taken at the end of two or three weeks.

4 The main point in the treatment of fresh fractures is immediate and complete plaster immobilization of the wrist for about three months or until there is evidence of bone healing by roentgenologic examination.

5 From January 1943 to April 1945, 64 patients with fracture of the carpal scaphoid were admitted to this hospital. Only 39 patients, or 61 per cent, had received proper plaster immobilization of the wrist shortly after injury. In this group 34, or 87 per cent, of the fractures united. The average period of fixation was three months. Of the 25 patients not receiving immediate adequate treatment, nonunion developed in 96 per cent.

6 Nonunion was found in 29, or 45.3 per cent, of the total 64 cases in the series. Twenty patients were operated on, 17 by me and 3 by others at different hospitals. The operative procedures employed were excision of the proximal fragment, drilling of the bone and bone graft.

7 Firm bony union was obtained in 4 cases. In 4 others, there was roentgenologic evidence of union but the fracture line was still visible four to six months after operation. In 2, there was no union following bone graft and an excision of the proximal fragment was performed. Three patients are under treatment, 1 by drilling and 2 by bone grafts.

8 The presence of nonunion is not in itself an indication for operation. The main criterion for operation is nonunion associated with persistence of clinical symptoms and disability and with the patient unable to perform his regular duties.

9 In selection of patients for operation, an attempt should be made to rule out those showing psychoneurotic traits or harboring a desire to avoid going back to duty. Unless this is done, the best operative results may prove unavailing and not alleviate the patient's complaints.

PENICILLIN OINTMENT—IMPREGNATED GAUZE IN THE LOCAL TREATMENT OF INFECTIONS

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LOCAL administration of penicillin, either alone or in combination with general administration, is often advantageous in the treatment of localized infections in accessible sites. However, the commonly used means of topical application have certain disadvantages. For example, sprinkling of penicillin powder on infected surfaces does not carry the material into crevices and tracts, and as Bodenham¹ has pointed out, the drug may be too rapidly absorbed and excreted by the body, moreover, powdered sodium penicillin in undiluted form is somewhat irritating to the tissues. The instillation of penicillin solutions, though satisfactory in situations in which the instilled material is well retained, is often inefficient because the solution drains away from all but the more dependent portions of the lesion. Gauze packs soaked in penicillin solution require relatively large amounts of the drug, and there are often technical difficulties in maintaining contact with all parts of the lesion and in keeping the dressings properly moistened. Penicillin ointments and creams, as described by Florey and Florey,² Clark and co-workers,³ Bodenham¹ and Taylor and Hughes,⁴ are often valuable preparations, but as ordinarily used they may not attain and maintain adequate contact with infected surfaces.

In order to obviate these disadvantageous features of current means of local penicillin therapy, penicillin ointment-impregnated gauze was devised. This material is convenient, effective and economical to use. Its preparation, its characteristics and some of its clinical applications are described herewith.

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¹ Bodenham, D C. Infected Burns and Surface Wounds. The Value of Penicillin, *Lancet* **2** 725 (Dec. 11) 1943.

² Florey, M E, and Florey, H W. General and Local Administration of Penicillin, *Lancet* **1** 387 (March 27) 1943.

³ Clark, A M, Colebrook, L, Gibson, T, and Thompson, M L. Penicillin and Propamidine in Burns. Elimination of Haemolytic Streptococci and Staphylococci, *Lancet* **1** 605 (May 15) 1943.

⁴ Taylor, P H, and Hughes, K E A. Infective Dermatoses Treated with Penicillin, *Lancet* **2** 780 (Dec 16) 1944.

PREPARATION OF PENICILLIN OINTMENT-IMPREGNATED GAUZE

The preparation of penicillin ointment-impregnated gauze involves, first, the preparation of the ointment and, second, the impregnation of sterilized gauze strips with the ointment

Penicillin Ointments—A number of ointment bases, both alone and in combination, were tested to determine the facility with which they liberate penicillin and also to determine the rate of inactivation of the contained drug. This search for a suitable ointment was instituted because of the paucity of data concerning the activity and the stability of penicillin ointments and because some of the more commonly used preparations were unstable, lasting only ten to fourteen days at 4 C.⁴

In vitro tests for the antibacterial activity of ointments were carried out by means of the cup plate method. Cups, 15 mm in diameter were punched in agar seeded with *Staphylococcus aureus*. In these cups

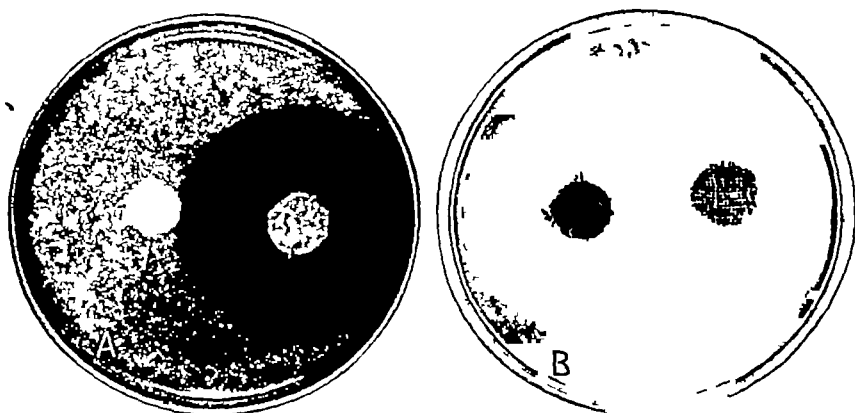


Fig 1—Agar plates seeded with *Staph aureus* and treated with penicillin preparations. A, penicillin ointments after five months at 4 C: left, penicillin in Aquaphor, showing complete loss of antibacterial activity; right, penicillin in Aquaphor, but with 1 part of Carbowax 1500 to 8 parts of Aquaphor. B, left, penicillin ointment (Aquaphor-Carbowax base, 5:1 ratio) filling cup punched out of the agar; right, penicillin gauze impregnated with the same ointment placed on the surface of the agar.

were placed the ointments to be tested, and after incubation at 37 C for twenty-four hours the distance from the edge of the cup to the farthest limits of inhibition was measured (fig 1 A).

Ointments made up in bases such as hydrous wool fat, Aquaphor, Hydrosorb, Qualatum, Carbowaxes of various molecular weights and combinations of Aquaphor and Carbowax⁵ were tested for antibacterial

⁵ Aquaphor, Hydrosorb, and Qualatum are oil in water emulsion type bases manufactured by the Duke Laboratories, Inc., Abbott Laboratories, and Almay, Inc., respectively. Carbowaxes are water-soluble waxlike solid polyethylene.

potency A sodium penicillin solution containing 5,000 Oxford units per cubic centimeter was incorporated into these bases in a ratio of 1 part of the solution to 9 parts by weight of the base, making a potency of 500 units per gram of ointment

While all the ointments tested gave good inhibition of the organisms, it was evident that those composed of or containing Carbowax gave greater zones of inhibition than the others Thus, the average zone of inhibition produced by freshly made hydrous wool fat, Aquaphor and Hydrosorb ointments was 11.9 mm, while the average of the ointments containing Carbowax was 18.8 mm (fig 2) Moreover, the activity of the penicillin was lost more slowly in ointments containing Carbowax (fig 1 A) After seventy days the average loss of activity in Aquaphor, the most effective ointment not containing Carbowax, was 26.5 per cent

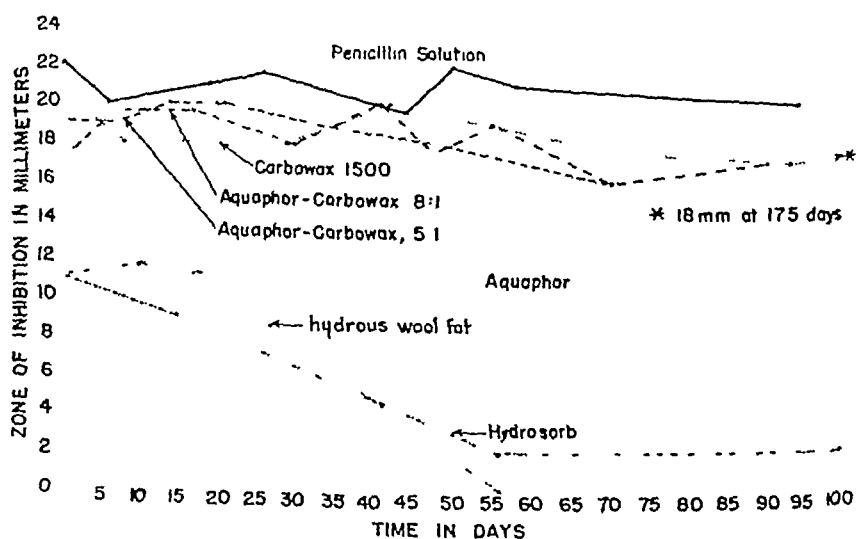


Fig 2—Curves showing the ability of six penicillin ointments to inhibit *Staph aureus* after periods of storage in the refrigerator. The ointments containing Carbowax gave greater inhibition and lost their potency more slowly than those not containing Carbowax, in fact they lost their potency only a little more rapidly than did the control solution of penicillin. The ointments all contained 500 units of penicillin per gram, the penicillin solution contained 5,000 units per cubic centimeter, and 1 drop was used.

as compared with the average loss of 11.7 per cent for the three ointments containing Carbowax (fig 2). The rate of inactivation of the Carbowax-containing ointments was not appreciably greater than that of a penicillin solution containing 5,000 units per cubic centimeter of isotonic

glycols manufactured by the Carbide and Carbon Chemicals Corp., they consist of mixtures of polyethylene glycols of varying molecular weights. Thus, Carbowax 1540 consists of a number of compounds with an average molecular weight of 1540. Carbowax 1500 is a 50:50 mixture of Carbowaxes 1540 and 300.

solution of sodium chloride, which lost 6 per cent of its activity in seventy days (fig 2)

The reason for devising mixtures of Aquaphor and Carbowax was that the ointments composed of Carbowax alone did not have the desired physical characteristics over the range of temperatures at which the ointments were used. Thus Carbowax 1500 and 1540 when containing penicillin solution were liquid at body temperature (98.6 F [37 C]). When Carbowaxes of higher molecular weight were added to correct this defect, the refrigerated ointment became too hard for easy spreading. Since the Aquaphor-Carbowax mixtures retain the advantages of effective liberation of penicillin and long retention of penicillin activity exhibited by the Carbowax ointments and yet retain their ointment characteristics, they have been adopted for use not only as ointments but also in the preparation of penicillin gauze. The optimum Aquaphor-Carbowax ratio was found to be 5 to 1.

A satisfactory ointment containing 500 Oxford units of penicillin per gram is prepared according to the following formula: 150 Gm of Aquaphor, 30 Gm of Carbowax 1500 and 100,000 units of sodium penicillin dissolved in 20 cc of isotonic solution of sodium chloride. The Aquaphor-Carbowax mixture is sterilized by autoclaving and is cooled to 65 C, at which temperature the penicillin solution is added with vigorous stirring until solidified or until poured on gauze strips. As penicillin becomes more plentiful, it may be advisable to increase the potency of the ointment to 1,000 units per gram. The ointment is stored in the refrigerator, where the loss of activity is less than one fourth as rapid as at room temperature.

Penicillin Gauze—Penicillin gauze is prepared by pouring the melted penicillin ointment described on sterile gauze strips cut from 2 inch (5 cm) roller gauze bandages into lengths of about 7 inches (18 cm). The ointment, melted by heating to not over 65 C, is evenly distributed through the gauze, and the material is allowed to stand in the warm room (37 C) for an hour to complete the even impregnation of the gauze. Thereafter the penicillin gauze is stored in the refrigerator, where it retains its activity for six months or more.

Two hundred grams of ointment being used for each one hundred and fifty strips, the gauze is thoroughly impregnated and yet the meshes are left open. It may be calculated that since the ointment contains 500 units of penicillin per gram each strip contains 665 units, while each square centimeter of gauze contains approximately 74 units.

CHARACTERISTICS OF PENICILLIN GAUZE

A single layer of penicillin gauze, 1 cm in diameter, placed on the surface of an agar plate seeded with *Staph aureus* gave an average zone

of inhibition of 12 mm from the edge of the gauze after twenty-four hours' incubation in a series of sixteen tests. A 15 mm disk of penicillin gauze gave almost as much inhibition as a 15 mm cup of ointment (fig 1 B). Obviously, penicillin ointment-impregnated gauze effectively liberates the penicillin under these conditions.

An increase in the number of layers of gauze applied to an agar test plate gave slightly increased zones of inhibition. In one test using penicillin gauze made with penicillin in Aquaphor ointment, the inhibition was as follows: one layer, 8 mm, two layers, 11 mm, and three layers, 13 mm. In a test using gauze impregnated with a penicillin ointment with a Carbowax-Aquaphor base, the inhibition was as follows: one layer, 16 mm, two layers, 16.5 mm, and three layers, 16.5 mm.

How long does the penicillin persist in the penicillin gauze when applied to an infected lesion? To answer this query, pieces of gauze 1 cm in diameter were cut from strips which had remained in the lesions of patients for twenty-four and forty-eight hours, and these were tested on agar plates inoculated with *Staph aureus*. Similar disks of unused penicillin gauze were simultaneously tested for controls. In fourteen such tests the average zone of inhibition exhibited by the gauze used for twenty-four hours was 50.4 per cent of that of the unused gauze. Thus, if a penicillin gauze strip containing 665 units is used in a wound, about half, or 335 units, is steadily fed into the infected surface over the twenty-four hour period. That the penicillin is largely fed into the wound instead of being inactivated by the body heat is indicated by the finding that penicillin gauze when hung up in an incubator at 37 C for twenty-four hours loses only 14 per cent of its activity.

The rate of penicillin loss is much more rapid when there is profuse drainage through the gauze. Thus, in 2 patients, 1 having a salivary fistula and the other epiphora from an exposed eyeball, the saliva and tears respectively carried away all the penicillin so that the penicillin content of the gauze was reduced to zero after twenty-four hours. The presence of penicillin-resistant organisms may also accelerate the loss of potency. The presence of fever was not observed to increase materially the rate of inactivation of penicillin gauze.

Two assays of penicillin gauze after a forty-eight hour sojourn in infected lesions revealed no activity in one and the persistence of 31 per cent of the original activity in the other. These results suggest the advisability of daily dressings for maximum therapeutic effect.

Pus removed from an abscess into which penicillin gauze had been inserted twenty-four hours previously was tested by the agar cup plate method. A zone of inhibition of 9 mm was observed, this was about the same degree of inhibition as that produced by a solution containing 5 units of penicillin per cubic centimeter. Pus from another abscess, in

which there was a moderate number of penicillin-resistant staphylococci gave only 2.5 mm inhibition after a twenty-four hour period. Pus from a similar lesion but after a forty-eight hour interval after the insertion of the gauze gave no inhibition.

TECHNIC FOR CLINICAL USE OF PENICILLIN GAUZE

It cannot be too strongly emphasized that penicillin gauze is not intended to replace established surgical procedures such as those required for the establishment of free drainage and for the removal of devitalized tissue. However, the effective local therapy attained with penicillin gauze may often make it feasible to use more conservative measures than usual.

Technic of Application—For infected flat surfaces, penicillin gauze is simply laid on the lesion and covered with a sterile cotton or gauze dressing. If the surface is irregular, care is exercised to press the gauze into each crevice and then to pack cotton into these depressions before the final dressings are applied. A single layer of penicillin gauze is ordinarily used because if there is any drainage it is desirable to allow it to pass through the meshes of the gauze so that the medicine is not pushed away from the treated surface by collections of exudate. If, however, there is little drainage and maximum penetration is desired, two or three layers of gauze may be applied.

For infected tracts, penicillin gauze may be inserted as a wick. When the discharge is copious and the opening is not wide, it may be desirable to use a slender wick so that the drainage is not blocked. If the discharge is moderate, the tract or cavity may be packed tightly with the gauze.

Ordinarily, the penicillin gauze dressings are changed daily because, as previously mentioned, the penicillin content is largely used up in forty-eight hours. When the infection is not severe, however, less frequent dressings are satisfactory. Other circumstances may also require less frequent dressings, as, for example, over skin grafts which might be pulled off by disturbance of the dressing too early.

Inasmuch as there are a number of organisms which are insensitive to penicillin, it is imperative that an aseptic technic be used. The chances of more bacteria being carried into the lesion are reduced by application of an antiseptic to the surrounding skin.

Tests for Sensitivity of Organisms to Penicillin—It is desirable to determine as soon as possible whether or not the organisms producing a given infection are sensitive to penicillin. This may be done by any of a number of sensitivity tests, but the radial streak method, described

elsewhere,⁶ has the advantage of being simple and convenient as well as being accurately quantitative. With this test one may test material from several lesions simultaneously by streaking it radialwise on a blood agar plate and then placing a disk of penicillin gauze in the center. The sensitivity of the organisms to penicillin may be determined after as short a period of incubation as eight hours. The degree of sensitivity is expressed in per cent, the inhibition of *Staph aureus*, strain 209-P,⁷ being taken as 100 per cent (fig 3). Infections caused by organisms with a sensitivity reading of 50 to 150 per cent usually respond dramatically to local therapy with penicillin ointment-impregnated gauze. When the organisms show a sensitivity of 10 to 50 per cent, the response

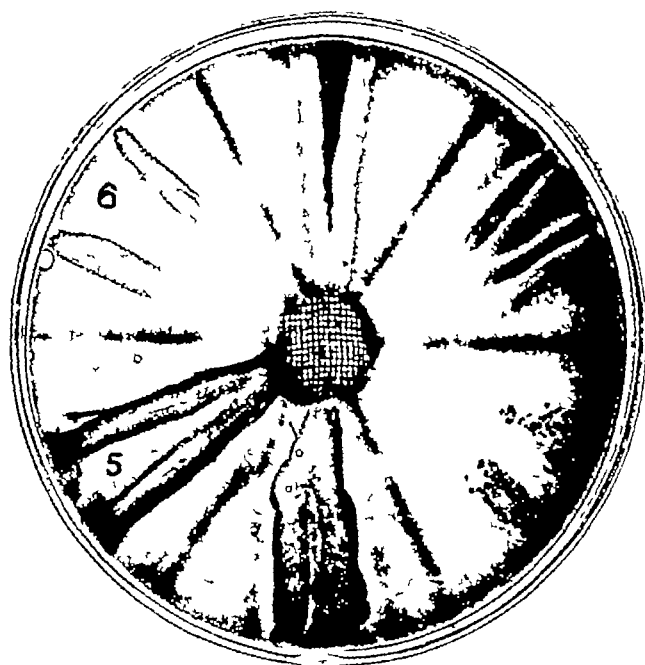


Fig 3—"Radial streak" test to determine the sensitivity to penicillin of organisms from infected lesions. Sector 1, *Bacillus coli* from a furuncle which did not respond to penicillin gauze. Sensitivity, zero. Sector 2, *Staph aureus* from furuncle cured by penicillin gauze (case 1). Sensitivity, 106 per cent. Sector 3, *Staph aureus* from a carbuncle cured by intramuscular penicillin plus penicillin gauze (case 2). Sensitivity, 131 per cent. Sector 4, *Staph aureus* from facial folliculitis not cured by penicillin gauze. Sensitivity, 6 per cent. Sector 5, *Staph aureus* from post-chemosurgical wound after removal of an old burn ulcer. Infection not cured by penicillin gauze. Sensitivity, zero. Sector 6, control *Staph aureus*, strain 209-P. Sensitivity, arbitrarily taken as 100 per cent. The light zone around some of the streaks represents hemolysis.

6 Mohs, F. E. A Simple Quantitative Test for the Penicillin Sensitivity of Bacteria. The "Radial Streak" Method, *J Lab & Clin Med* 30:800 (Sept.) 1945.

7 A culture of *Staph aureus* 209-P was obtained from the Food and Drug Administration through Dr. Albert C. Hunter.

is apt to be less dramatic but, nevertheless, favorable. A sensitivity below 10 per cent usually means that the clinical response will be sluggish or absent and that other means of therapy are indicated.

THERAPEUTIC RESULTS IN INFECTIONS TREATED WITH PENICILLIN GAUZE

A total of one hundred and four lesions were treated locally by means of penicillin ointment-impregnated gauze. In this group there was no instance of allergic or other untoward reaction to the medicine.

Furuncles—Eleven furuncles in the pointing stage were conservatively incised, the pus gently removed and the cavity packed with penicillin gauze. All were sterilized within a few days (often by forty-eight hours) with one exception, a large boil over the lumbar portion of the spine caused by *Bacillus coli*, which was completely resistant to penicillin (fig 3, sector 1). Associated with the rapid sterilization of these lesions was a correspondingly rapid clinical improvement. In patients who had previously had similar lesions there was noted a more rapid recovery with penicillin gauze therapy than with treatments previously used, the case of a patient illustrating this point follows.

CASE 1—In the patient, F H B, aged 54, during the course of one week a greatly inflamed and painful furuncle, 2 cm in diameter, developed on the dorsum of the hand. It had just pointed and was beginning to discharge grayish pus. The opening was sufficient to allow the removal of some of the pus and the insertion of a strip of penicillin gauze measuring 5 by 30 mm. A single layer of penicillin gauze 2 cm in diameter was applied to the surface of the skin and a gauze dressing applied. Smears and cultures revealed *Staph aureus*, and the radial streak test showed the penicillin sensitivity to be 106 per cent (fig 3, sector 2).

By twenty-four hours there was less inflammatory reaction, but smears showed an occasional organism and the cultures showed staphylococci. By forty-eight hours, however, no organisms were found by smear or culture. Clinically, all the soreness and most of the inflammation had disappeared. Cultures taken four days later were also negative. When last seen, nine days after the first visit, the lesion was healed.

This patient had previously had furuncles of similar nature, which had taken one week to develop, one week to drain and one week to heal. It is estimated that the rapid sterilization produced by the local penicillin gauze therapy shortened the duration of the process by at least five days.

Carbuncles—A large carbuncle on the back of the neck was treated. It responded well to local penicillin gauze therapy, though it had not responded satisfactorily to either sulfadiazine or intramuscular therapy with penicillin.

CASE 2—In the patient, S E W, aged 67, several "bunches" on the back of the neck developed sixteen days before the institution of penicillin gauze therapy. Four days after the onset one of the masses had broken open, discharging much pus, and during the next few days several more openings developed. The patient's

condition became worse despite hot wet packs and sulfadiazine, 1 Gm every four hours for five days. On admission to another service, his temperature was 100 F. The tender inflamed mass, which involved the entire back of the neck, continued to drain large amounts of pus for the next five days, during which allantoin and urea packs were applied and penicillin was given intramuscularly in doses of 15,000 units every three hours. The temperature was reduced but did not stay normal.

When local penicillin gauze therapy was instituted the mass measured 10 by 11 cm and there were six tracts, which were from 24 to 62 mm deep (fig 4 A). About 150 cc of pus was expressed. Smears and cultures revealed numerous organisms identified as *Staph aureus*. The organisms were highly sensitive to penicillin, giving a reading of 131 per cent by the radial streak test (fig 3, sector 3).

Penicillin gauze wicks measuring 2.5 by 8.5 cm were inserted into the bottom of each tract with the use of a blunt probe. The intramuscular administration of penicillin was continued. By the next day the swelling had reduced to 8 by 8.5 cm. The amount of discharge became less each day, the temperature remained

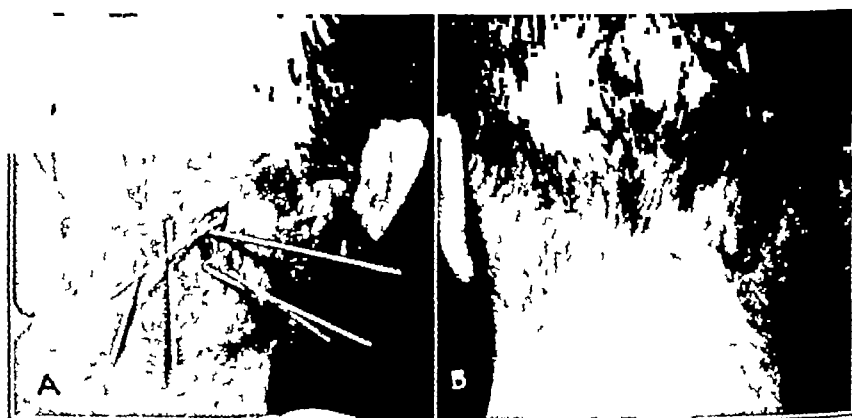


Fig 4—A, carbuncle with applicators inserted in six sinuses, the depths of which varied from 24 to 62 mm. B, after cure by intramuscular administration of penicillin plus insertion of penicillin gauze strips, showing minimal scar.

normal and the symptoms subsided, so after three days the intramuscular administration of penicillin was stopped and the patient was discharged from the hospital.

He returned daily for insertion of penicillin gauze. There was about 25 cc of pus each day, and cultures revealed staphylococci until the seventh day, when cultures became negative. As the tracts filled in from the bottom, the strips were shortened accordingly. Strips of penicillin gauze were placed on the skin over the central part of the carbuncle, and no new pustules developed there. However, a pustule, 5 mm in diameter, developed in the left postauricular region, and this responded rapidly to incision and the insertion of penicillin gauze. Further recurrences were obviated by the placing of penicillin gauze over the surrounding skin to eliminate the pathogens. In one month the lesion had healed. The final scar was minimal (fig 4 B).

Other Surface Infections—Thirty-one other surface infections were treated by the application of penicillin ointment-impregnated gauze. The results were as follows: four infected diabetic ulcers, cured, three

stasis ulcers two cured and one improved, three cases of paronychia, cured, two areas of cellulitis around navel in infants, cured, three areas of cellulitis elsewhere, cured, three areas of infective eczematoid dermatitis, cured, one chronic indolent ulcer on neck, cured, three infected burn ulcers, cured or much improved, one infected corn, improved temporarily, but lymphangitis developed, which responded to oral administration of sulfadiazine, three areas of impetigo, cured in two to four days, two infected sebaceous cysts, infection subsided, and three areas of pustular folliculitis two cured and one not improved. The last infection was the only one in this group of predominantly staphylococcal infections which did not show some degree of favorable response, it was caused by a strain of *Staph aureus* with a sensitivity of only 6 per cent, as determined by the penicillin sensitivity test (fig 3, sector 4)

Postoperative Wounds—Penicillin gauze may be used in postoperative wounds either for the prevention of infection or for the treatment of established infections. In the chemosurgery clinic, thirty-one wounds following chemosurgical excision of cancers⁸ from locations where the avoidance of contamination was difficult were dressed with penicillin gauze. All but two responded satisfactorily. One was a lesion infected with a strain of *Staph aureus* with a sensitivity of zero as determined by the radial streak test, this infection responded promptly to scarlet red gauze,⁹ and healing then proceeded uneventfully. The other exception was a temporal wound with a large area of exposed temporal bone, while the *Staph aureus* producing the infection was originally fairly sensitive to penicillin (36 per cent), the presence of the dead bone prevented rapid sterilization and the organisms became less sensitive (19 per cent), with consequent worsening of the infection. Switching to streptomycin ointment-impregnated gauze, to which the organisms were more strongly sensitive (73 per cent), resulted in prompt and complete sterilization of the wound.

After the amputation of gangrenous parts by chemosurgical treatment,¹⁰ penicillin gauze was found effective in avoiding infections in patients whose resistance was lowered by diabetes and arteriosclerosis. In 11 patients healing was uncomplicated by infection, even though in 2 healing was slow due to severe circulatory impairment. The complete lack of any irritating effect on the tissues by the penicillin gauze was especially advantageous in this group.

8 Mohs, F. E. Chemosurgery. A Microscopically Controlled Method of Cancer Excision, *Arch Surg* **42** 279 (Feb.) 1941

9 Bettman, A. G. A Simpler Technic for Promoting Epithelization and Protecting Skin Grafts, *J. A. M. A.* **97** 1879 (Dec. 19) 1931

10 Mohs, F. E., Severinghaus, E. L. and Schmidt, E. R. Conservative Amputation of Gangrenous Parts by Chemosurgery. *Ann Surg* **114** 274 (Aug.) 1941

Seventeen other postchemosurgical wounds following the removal of two radiation ulcers, three plantar warts, two infected pilonidal cysts, one blastomycotic lesion, four nevi, one keratosis, one chronic infection, one hemangioma and two infected burn ulcers, all healed uneventfully with the exception of one of the burn ulcers, which became infected with a strain of *Staph aureus* having complete resistance to penicillin, as indicated by the radial streak test (fig 3, sector 5)

On other services in this hospital penicillin gauze has been effective in the treatment of a number of infected incisions, stitch abscesses, post-mastoidectomy infections, infected tooth sockets and infected grafts. However, since bacteriologic studies are lacking for most of these cases, they are just mentioned here to give some suggestion of the variety of uses for penicillin gauze.

Osteomyelitis—Osteomyelitis in 2 cases was definitely improved but not completely sterilized by the use of penicillin gauze. In both cases the penicillin eradicated the chief pathogens, but the presence of dead bone allowed the persistence of a few penicillin-resistant organisms. Removal of the sequestrum appears to be essential for a complete cure.

COMMENT

The effectiveness of penicillin ointment-impregnated gauze in the local therapy of infections is probably due largely to the steady transfer of penicillin from the gauze to the infected tissues throughout the twenty-four hour period between dressings. As shown by the assays of penicillin gauze removed from wounds, about one half of the contained penicillin is transferred to the tissues during a twenty-four hour period. Since each square centimeter of penicillin gauze originally contains 74 units of penicillin, there is a transfer of about 37 units to each square centimeter in twenty-four hours.

That the penicillin is transferred to exudates is clearly indicated by the assays of pus from abscesses treated with penicillin gauze. Some of these tests showed levels well above the blood levels after parenterally administered penicillin. This capacity of penicillin gauze to maintain high local levels of penicillin over prolonged periods probably accounts for its ability to sterilize infections which are resistant to intramuscular administration of penicillin alone, as, for example, the carbuncle described in case 2. When there is some evidence of spread of infection from the local site, it is, of course, advisable to administer antibiotic substances by the systemic as well as by the local route. The dictum, enunciated by Meleney,¹¹ that local penicillin therapy ordinarily is

11 Meleney, F. L. Medical Progress. Some Practical Points in the Administration of Penicillin in the Treatment of Surgical Infections, New York Med (no 11) 1:15 (June 5) 1945.

sufficient in patients with temperatures below 101 F but that systemic administration is required when the temperature is higher appears to be valid

Although penicillin definitely is the most effective drug against infections caused by organisms which are sensitive to it, there is the unfortunate circumstance that some organisms are partially or completely insensitive to it. Luckily, most of the more strongly pathogenic microbes are sensitive to penicillin, and when these are removed from a lesion harboring a mixed infection there is often distinct clinical improvement.

Not infrequently, however, troublesome penicillin-resistant infections are encountered. For these it would be ideal to have on hand a variety of antibacterial agents impregnated in gauze, with tests to determine which is most effective for a given infection. A start in this direction has been made by the use of streptomycin ointment-impregnated gauze, this antibiotic drug is effective not only in lesions caused by most of the penicillin-resistant gram-negative bacilli but also against infections caused by penicillin-resistant strains of ordinarily penicillin-sensitive organisms, such as *Staph aureus*.

The impregnation of gauze with ointments is not new. Petrolatum and boric acid ointment gauze have been used for years. Scarlet red gauze as developed by Bettman⁹ has valuable antibacterial as well as epithelial stimulating activity. Ointment-impregnated gauze has several advantages over gauze on which ointment is spread. First, the former has open meshes through which exudates may freely pass so the medicine is not pushed away from the infected surface. Second, ointment-impregnated gauze lends itself better to close apposition to irregularly contoured lesions and to insertion into infected tracts and sinuses. Third, the reduced tendency for exudates to collect under ointment-impregnated gauze reduces the incidence of infective eczematoid dermatitis, which results from exudates contacting the skin around infected lesions.

SUMMARY AND CONCLUSIONS

The preparation of effective and stable penicillin ointments is described. The preparation, characteristics and clinical use of penicillin ointment-impregnated gauze are considered, and the results of local penicillin therapy with this agent in a series of 104 cases are reported.

The local therapy of infections by penicillin gauze facilitates the maintenance of effective levels of penicillin in wounds with a single application a day, with resultant savings in time and material. The accuracy with which penicillin gauze can be applied to and kept in constant contact with infected surfaces makes possible a steady transfer of the penicillin from the gauze to the infected tissues over prolonged periods.

ADDENDUM

The addition of various antibacterial agents to penicillin ointments for the purpose of eliminating the penicillin-resistant organisms in mixed infections has been found advantageous. Parachlorophenol in 1:400 concentration, as suggested by Meleney¹² is as effective as any agent tried so far. It is added to the Aquaphor-Carbowax mixture at the same time as the penicillin solution. The penicillin gauze with the added parachlorophenol may be used in the radial streak sensitivity test but if the sensitivity to penicillin itself is being tested for it is, of course, necessary to omit any additional antibacterial agents.

Prof. Paul F. Clark and Prof. Erwin R. Schmidt gave helpful advice, and Mrs. Eleanore Sweitzer gave technical assistance.

12 Meleney, F. L., Johnson, B. A., Pulaski, E. J. and Colonna, F. Treatment of Mixed Infections with Penicillin, *JAMA* **130**:121 (Jan. 19) 1946.

A SURGICAL SPECIMEN CONSISTING OF A PARTIALLY DEVELOPED PARASITIC FETUS

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GUAYMAS, SONORA, MEXICO

A MAN, in search of immediate medical attention, came to me as he wanted some doctor, the nearest doctor, to attend his deformed offspring, a son, who was suffering from bronchopneumonia

CLINICAL PICTURE

On examination of the child I discovered an amazing monstrosity—indeed the only one of its kind I have ever encountered—which had been under exhibition at a circus in a nearby town

He was a normal boy who had attached to his epigastrium a half-body (fig 1) consisting of a normal-shaped abdomen with an atrophied



Fig 1—A close-up of the epigastropagus

arm at the upper part and well developed thighs, legs, feet and genital organs at the lower part

As interesting details, I must mention that this monstrosity was able to urinate, did not have an anus (fig 2), presented only passive movements of adduction and abduction in his hip joints and had only four toes on each foot. Yet the development of this parasitic monstrosity was similar to that of the homologous parts of the boy (fig 3). During examination, the child showed no pain when the skin of the monster was pinched. There was no mobility or noise in the monstrosity which

might indicate the existence of heart and lungs and no reaction to galvanic current. Furthermore, there were no active movements.

The patient, J. I. L., was born in the state of Sinaloa, Mexico, on Dec. 28, 1944, his age at operation was 2 months and 23 days. During



Fig. 2—Passive movements of the monster.



Fig. 3—Rear view of the monstrosity. Note absence of anus.

pregnancy his mother had shown an intense positive reaction to the Wassermann test. There is no relationship between the parents. The pregnancy had been normal except for the fact that the mother allegedly felt many movements, birth occurred at the normal period.

Breast feedings were alternated with feedings of condensed milk. The laboratory examinations disclosed identical compositions for the two urines.

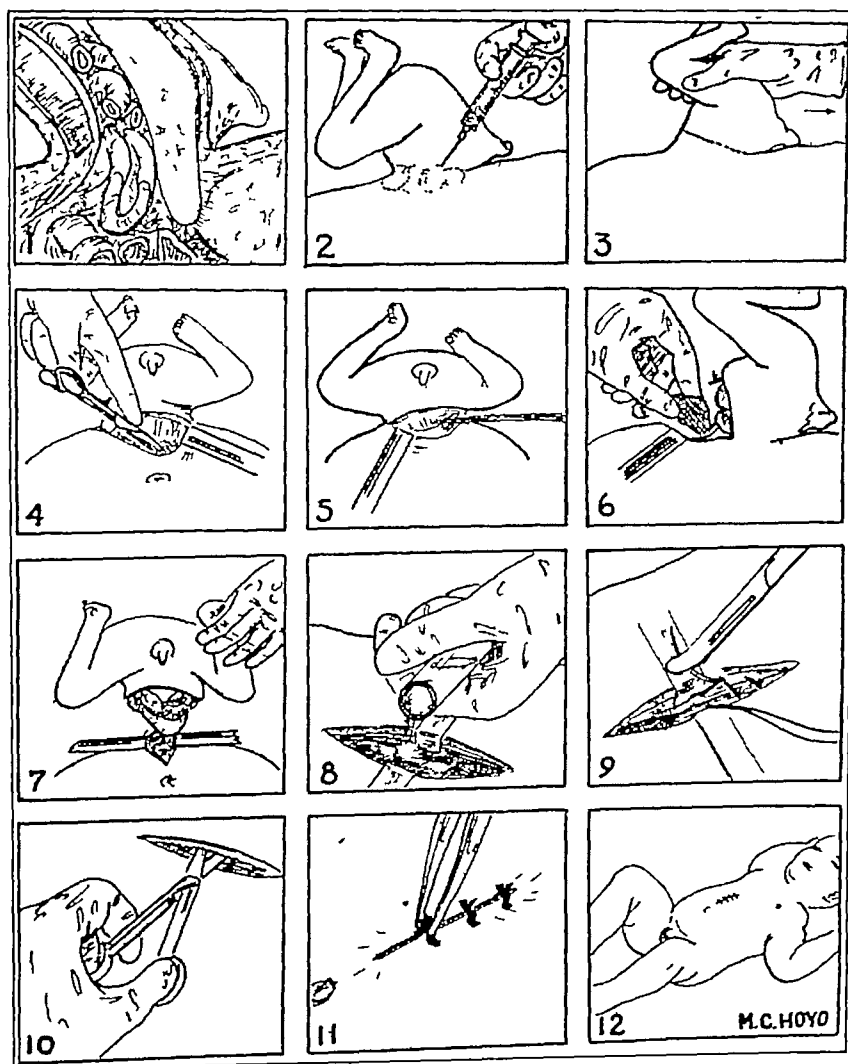


Fig 4—Drawings of the operation

After treating the child for bronchopneumonia, I suggested an operation basing my suggestion on the following considerations

1 It being established that the child's heart was subject to extreme exertion in pumping blood to both bodies, his life could not be guaranteed

2 When I compressed the junction of the two bodies there were no untoward reactions, and it convinced me that the organs of the monstrosity were unimportant

3 From the standpoint of esthetics, such a grotesque creature was doomed to misery

4 It was possible, without danger to the boy's life to make a surgical exploration to determine the feasibility of extirpating the monstrosity

CLASSIFICATION

The patient was a compound monster, pertaining to the order of double parasites belonging to the family heterotypus the genus and the species heteropagus epigastropagus (according to the classification of Geoffroy St Hilaire)



Fig 5—Two months later the patient is a normal boy. He has gained weight. The operative scar is shown.

OPERATION

During the preoperative period penicillin was administered. The operation (see fig 4) was performed with the patient under local anesthesia. A circular incision (about $5\frac{1}{2}$ inches [14 cm] in circumference) was made at the union of the bodies, including skin and fascia. The bladder of the monster was subjected to a blunt dissection and ligated in its upper pole.

After the intestines of the monstrosity—inflamed and containing yellow pus—were found tightly adherent to those of the child, with

some difficulty it was possible to separate them. An analysis disclosed no germs in the pus. Finally, an atrophied liver was found joined to the normal liver of the child, it also being possible in the end to separate it. A semi-important artery and vein were ligated at the upper part of the fascia. After 2.5 Gm of sulfathiazole had been placed inside the cavity, the different structures of the abdomen were sewed with surgical gut. The child's efforts prevented the use of clips for the skin.

POSTOPERATIVE COURSE

The temperature after the operation was 38 to 39.5 C (100.4 to 103.1 F) for the first two days, it was 41 C (105.8 F) at forty-eight hours, receding after a bath. Penicillin (30,000 units) was administered daily for two days in a solution of dextrose and isotonic solution of sodium chloride.

A superficial disruption of the wound forced me to mobilize the skin by undercutting and to sew it again, but there were no further complications.

At the end of eight days, the child presented good appetite, had regular bowel movements, urinated normally and had gained weight. Now, two months later (fig. 5) he is a normal boy.

I have not dissected the monstrosity, as I wish to have a specialist do it.

It is not my desire to generalize, inasmuch as this is a case completely abnormal.

Dr. Ramirez Ruiz helped as first assistant in the operation, and Nurse Rosa Maria Mercado took care of the baby before and after the operation.

EDITH L. POTTER, M.D., Ph.D.
CHICAGO

THE specimen described by Dr. Luis Pavon Sarrelangue was received in my laboratory Dec. 22, 1945. It consisted of two lower limbs which were attached to a mass resembling the lower part of an abdomen (fig. A). The upper portion had been severed from the abdomen of the child to whom it was attached. This operation took place two months and twenty-three days after birth.

Roentgen examination revealed well developed bones in the lower extremities (fig. B). Each extremity presented a femur, tibia, fibula.

From the Department of Obstetrics and Gynecology, the University of Chicago, The School of Medicine and the Chicago Lying-in Hospital of the University of Chicago.

vessels contained a large number of immature red blood cells. Sections from the uppermost portion of the abdominal cavity showed a diffuse infiltration of inflammatory cells.

The surgeon stated that a small liver belonging to this portion of the infant was found at operation. None was present in the specimen at the time of examination.

SUMMARY

A parasitic fetus consisting of two legs and the lower part of the abdomen which had been surgically removed from its point of attachment to the anterior abdominal wall of an infant 2 months and 23 days old was observed. Each lower limb possessed a femur, tibia, fibula, tarsal bones, four metatarsal bones and three terminal phalanges attached to each tarsal bone, pubic ram and a common iliac bone composed the pelvis. No spine was present. Within the abdominal cavity were intestine, bladder, kidney and ureter. Surrounding the urethra near its connection with the bladder was a prostate gland, and extending upward from it were seminal vesicles.

REVIEW OF UROLOGIC SURGERY

ALBERT J SCHOLL, M D
LOS ANGELES

FRANK HINMAN, M D
SAN FRANCISCO

ALEXANDER B HEPLER, M D
SEATTLE

ROBERT GUTIERREZ, M D
NEW YORK

GERSHOM J THOMPSON, M D
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ROCHESTER, MINN

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KIDNEY

Hydronephrosis—Gibson¹ classified the type of obstruction that causes hydronephrosis at the ureteropelvic junction, evaluated the methods of surgical treatment and emphasized the factors that contribute to the successful outcome of the operation

Obstructions of the ureteropelvic junction may be divided advantageously into three types or groups (1) kinking and distortion at the ureteropelvic junction by extrinsic adhesions, fibrous or vascular bands or anomalous vessels, (2) intrinsic obstruction at the ureteropelvic junction by strictures from thickening of the musculature, hyperplastic fibrous tissue and a fibrous contracture producing a small stoma, and (3) another type of intrinsic obstruction from valve formation, caused by high insertion of the ureter into the pelvis. These types of obstruction may coexist. The inner caliber of the ureteropelvic junction cannot be determined accurately by external inspection or palpation. Therefore, if extrinsic obstruction is present, the surgeon should not be content in believing that it is the sole cause of the hydronephrosis until he has opened the pelvis through a small incision and calibrated the ureteropelvic junction. This can be done with the tip of a hemostat or a 12 to 14 F bougie passed downward through the ureteropelvic junction.

1 Gibson, T E. Hydronephrosis. Classification and Plastic Repair of Ureteropelvic Obstructions, Surg., Gynec. & Obst. 80:485-496 (May) 1945

Gibson has divided the numerous pyeloplastic procedures into four basic types (1) reimplantation of the sectioned ureter into the pelvis at its most dependent part (Kuester), with or without excision of the redundant pelvis, (2) longitudinal incision and transverse closure (Fenger), (3) a Y incision with a V closure (Schwyzer and Foley), and (4) lateral anastomosis of pelvis and ureter (the original Trendelenburg operation, of which there are many interesting and useful variations)

Gibson said that ureteral splinting and intubation, with the necessary nephrostomy, pyelostomy or ureterostomy drainage, is the most important single factor that contributes to a successful end result in this highly technical field. He has found that the various types of nephrostomy tubes, with ureteral catheters and splints attached, are unsatisfactory because the splinting portion of the tube which goes down the ureter is not sufficiently rigid and tends to pass backward into the pelvis, where it coils and completely defeats its purpose.

The T tube offers a much more satisfactory type of drainage both for nephrostomy and for ureteral splinting. It can be cut to size and is easily introduced and removed. It can be used just as readily for ureterostomy as for nephrostomy. Splinting and drainage should be maintained for ten days to three weeks or more, depending on the apparent needs in the individual case.

Gibson said that pyeloureteral splinting and intubation with a T tube does away to a large extent with the necessity of elaborate plastic operations and the delicate suturing they entail.

Adequate exposure is essential for any type of pyeloplasty. The twelfth rib is removed to facilitate adequate exposure, which is essential to the proper performance of any type of pyeloplasty.

In the first type of obstruction, the extrinsic, a simple pyeloureterolysis with nephropexy is all that is necessary. However, the lumen of the ureteropelvic junction should be calibrated before the operation is concluded, and ureteral splinting should be employed if there is much peripelvic and periureteric fibrosis, with angulation or distortion of the upper part of the ureter.

In the second type of obstruction, that is, intrinsic obstruction due to fibrosis and stricture at the ureteropelvic junction, a variety of procedures is available. Gibson prefers the Davis-Rammstedt operation. The pelvis is opened between stay sutures. A Mayo hemostat is pushed down through the ureteropelvic junction, and its jaws are spread gradually until the lumen is more than adequate. Simultaneously, a row of parallel vertical incisions is made about the outside and extended down to the mucosa in order to divide the constricting muscle fibers and scar tissue. This step is followed by splinting or intubation to maintain the caliber of the lumen at 12 to 14 F until

healing is complete. If this is not feasible, other procedures are available, such as the ureteropyeloneostomy of Kuester or Lubash, or the Schwytzer-Foley methods may be used, with success, in type 2 obstruction.

For type 3 obstruction, involving valve formation with high insertion of the ureter in the pelvis, the original Trendelenburg operation is still eminently satisfactory. This may be modified to include excision of a large part of the redundant renal pelvis, as advocated by Priestley. In type 3 obstruction, one may also use the reimplantation methods of Kuester or Lubash or the anterior or posterior plastic operation of Schwytzer and Foley.

Gibson regards adequate splinting and intubation as more important in obtaining a good result than the most painstaking suturing. The end results in several cases of advanced hydronephrosis in solitary kidneys were cited to support Gibson's contention.

Anomalies—Goyanna and Greene,² in considering duplication of the renal pelvis and ureter, stated that the commonest associated pathologic condition is hydronephrosis or hydroureter or both. Duplication is twice as common on the right side as it is on the left side, and hydronephrosis is nearly twice as common in the lower segment. The higher incidence of pyelonephritis, pyonephrosis and atrophic pyelonephritis in the lower segment may be considered a consequence of the faulty drainage of the hydronephrotic kidney. In all cases of ectopic ureter and in all cases in which ureterocele is associated with duplication, the ureter from the upper pelvis was the one affected.

The following roentgenographic signs are suggestive of duplication: (a) elongated renal shadow, (b) presence of a region of kidney with no means of drainage and (c) characteristic shape of the visualized pelvis. Excretory urography alone cannot be depended on to distinguish complete duplication from incomplete duplication of the ureter unless the entrance of both ureters into the bladder is clearly seen. Cystoscopy and retrograde pyelography, although helpful, may fail when the supernumerary orifice is hidden or when the duplication is incomplete. A history of congenital incontinence associated with normal micturition is strongly suggestive of duplication and an ectopic ureter.

Nation³ reported 34 instances of horseshoe kidney that were disclosed in 15,728 autopsies, an incidence of 1/468 bodies examined. Twenty-seven (79 per cent) of the patients were men, and 7 (21 per

2 Goyanna, R., and Greene, L. F. The Pathologic and Anomalous Conditions Associated with Duplication of the Renal Pelvis and Ureter. *J Urol* 54: 1-9 (July) 1945.

3 Nation, E. F. Horseshoe Kidney. A Study of Thirty-Two Autopsies and Nine Surgical Cases, *J Urol* 53: 762-768 (June) 1945.

cent) were women. Horseshoe kidney is approximately 38 per cent, or 2.6 times, commoner in men than in women.

Of the patients who were found at autopsy to have horseshoe kidneys which had not been apparent clinically, 45 per cent had had a blood pressure above 140 systolic and 90 diastolic in millimeters of mercury and 30 per cent had had a blood pressure above 170 systolic and 110 diastolic. The corresponding percentages of patients without horseshoe kidney were 45 and 15 respectively.

The range in weight of the horseshoe kidneys was from 230 to 550 Gm., the extremes deviating because of disease. The mean was 342.3 Gm. and the median and the mode were 300 Gm. Thirty-three of the patients had not complained of symptoms thought to result from the horseshoe kidney. In only 1 patient was death the result of apparent renal disease; in this case, the patient had malignant nephrosclerosis.

Nephritis was not found more commonly than expected in such a group of cases.

The author also reported 9 cases of horseshoe kidney in which operation was performed between 1934 and 1941. The ages of the patients ranged from 9 to 59 years. Seven of the patients were men, and 2 were women.

Five patients had a normal blood pressure, and 2 of the patients who had hypertension were cured by renal operation.

The symptoms complained of were the result of the pathologic processes rather than of the renal fusion. Pain was the commonest symptom.

Six of the 9 patients had renal calculi. The other 3 had obstruction and dilatation, with pyonephrosis.

In only 3 cases were symphysiotomy and nephropexy performed.

Five patients obtained partial or complete relief. The other 4 had progressive changes, and the results were poor.

Horseshoe kidney alone does not cause or predispose to hypertension. The average horseshoe kidney is slightly more than twice the size of a normal kidney. Horseshoe kidney is compatible with comfort and good health; it causes appreciable symptoms in a minority of cases. Most symptoms are caused by renal disease rather than by renal fusion.

Infection—Heaney and Kretschmer,⁴ in considering pyelitis of pregnancy, stated that in a series of 9,802 cases of pregnancy there were 31 cases of pyelitis, or an incidence of only 0.3 per cent.

⁴ Heaney, N. S., and Kretschmer, H. L. Pyelitis of Pregnancy. Foci of Infection in Its Prevention, *J. A. M. A.* 128:407-408 (June 9) 1945.

Early studies disclosed that all patients with pyelitis of pregnancy had pronounced dilatation of the upper part of the urinary tract. Recently, Kretschmer and Heaney studied the urinary tract in 19 cases of normal pregnancy, by means of retrograde pyelograms. All the women were free of all signs and symptoms of infection of the urinary tract. In 47.36 per cent of the cases bilateral dilatation was found, and in 35.84 per cent the renal pelvis and ureter were dilated on one side only while in 15.8 per cent no dilatation was found. In 100 per cent of another series of cases, dilatation of the renal pelvis and ureter occurred during pregnancy and the puerperium. A striking feature of the dilatation was that it was almost uniformly above the brim of the pelvis. This study showed that dilatation is progressive with pregnancy.

In systemic diseases, bacteria frequently enter the blood stream through the kidneys and are eliminated through the urine. When the kidneys are sound and the urinary tract is open the organisms escape without injury of the urinary tract, but when obstruction to the urinary tract is present pyelitis may result. Pyelitis develops after acute colds and not infrequently during acute infectious diseases such as measles. In children's hospitals and orphanages, pyelitis commonly occurs after gastroenteritis. Pyelitis of pregnancy may occur after acute food poisoning. Heaney and Kretschmer reiterated the importance of the routine eradication of foci of infection in the preparation of women for expected pregnancy.

They made an analysis of the hospital records of the 31 patients who had pyelitis. In 2 cases the records were incomplete, and in 2 others no foci of infection were recorded, thus leaving histories of 27 cases for consideration in this study. There were 17 patients with one focus, 4 with two foci, 3 with three foci, 2 with four foci and 1 with five foci.

Heaney and Kretschmer said that pyelitis of pregnancy is a preventable disease or, if not completely preventable, the incidence of its occurrence can be reduced to a minimum.

Aneurysm—Blain, Glynn and Hiratzka⁵ reported a case in which a dissecting aortic aneurysm involved a renal artery and simulated acute nephrolithiasis. They stated that the literature contains reports of 15 cases in which a dissecting aneurysm of the aorta caused hematuria or other urologic symptoms. In most of the cases the symptoms simulated those of an acute urologic disease. In 9 of the 15 cases a correct diagnosis was made before autopsy. The authors reported

5 Blain, A., III, Glynn, T. P., and Hiratzka, T. Dissecting Aortic Aneurysm Involving a Renal Artery and Simulating Acute Nephrolithiasis. *J. Urol.* **53**: 753-761 (June) 1945.

a case in which the dissecting aneurysm involved the right renal artery and simulated acute right renal lithiasis. They cited a second case, in which a dissecting aneurysm involved the left renal artery and necessitated a consideration of acute left renal lithiasis in the differential diagnosis. In each case correct diagnosis and pathogenesis were suspected when the patients were admitted to the hospital.

Levine⁶ stated that aneurysms of the renal artery are rare and that as far as he has been able to determine only 76 cases of this lesion have been reported in the literature. In 13 of these cases, the diagnosis was made before operation or before the patients died.

In the case which he reported the patient was a woman, aged 59 years who complained of pain in her abdomen. A wreathlike calcific shadow situated medially to the right kidney and above the hilar notch was observed in the roentgenogram. As this finding is considered typical of an aneurysm, a diagnosis of aneurysm of the renal vessels was made. An exploratory operation revealed a pulsating mass just medial to the right kidney. The kidney and the aneurysm were removed. The aneurysm was approached transperitoneally, as it was considered advisable to ligate the renal vessels before the aneurysm was mobilized. As a precautionary measure, tapes were passed under the vena cava, above and below the renal vessels.

Carbuncle—Shearer, Wiper and Miller⁷ reported a case of renal carbuncle in which the patient was treated with penicillin. The patient had had pain in the renal area for two months. Surgical exploration did not disclose any lesion. Retrograde and excretory pyelograms later revealed that the middle and lower calices of the left kidney were smaller than normal and pushed to the right. Another exploratory operation was performed. An aspirating needle was passed into several suggestive areas, and purulent material was obtained from a site deep in the substance of the kidney at the junction of the upper two thirds and lower third. The cavity was opened and a catheter inserted. Penicillin was administered intramuscularly, and the abscess cavity was washed out with a dilute solution of this agent. The patient responded well to treatment, the wound healed and healthy renal substance was conserved.

URETER

Papilloma—Ottley⁸ reported a case of benign papilloma of the ureter. The patient, a woman aged 71 years, had hematuria of

6 Levine, B. Aneurysm of the Renal Artery, *J Urol* **54** 17-21 (July) 1945

7 Shearer, T. P., Wiper, T. B., and Miller, J. M. Renal Carbuncle. A New Method of Treatment, *J Urol* **54** 12-16 (July) 1945

8 Ottley, C. M. A Case of Benign Papilloma of the Ureter, *Brit J Surg* **32** 531 (April) 1945

moderate degree On cystoscopy, ureteral obstruction was found on the right side Intravenous pyelography was performed, but none of the dye was excreted on this side Nephroureterectomy was performed There was a spindle-shaped enlargement at the lower end of the ureter Histologic examination revealed that the lesion was a benign papilloma The patient was alive and well three years later

BLADDER

Cord Bladder—Thompson⁹ discussed the restoration of function of cord bladders by transurethral operation

In some cases the cord injury may be minor in degree, and even though paralysis exists it is one sided or temporary in nature and normal micturition is disturbed either for a short period or not at all In the majority of cases, paralysis is so extensive that micturition is impossible and remains so for many months

In the early phase of the paralysis, the bladder of a few of the patients can be emptied by manual pressure applied in the suprapubic region As time goes on, however, these few usually find that more and more pressure must be applied and that the bladder cannot be completely emptied Finally, infection will develop, for infection follows stasis no matter where it occurs in the urinary tract The majority of paralyzed patients require drainage of the bladder

After a lapse of weeks or months, when the catheter is removed, some of the patients have what is loosely called an "automatic bladder" In other words, they void at irregular intervals but are usually incontinent to some degree, hence a urinal of some type must be worn at all times Thompson has never seen a patient afflicted with cord bladder who could accurately time the period of automatic voiding, catch the urine as it is voided and stay dry between times For this reason, drainage by catheter is usually continued indefinitely

If the indwelling catheter can be dispensed with, the patient's condition improves rapidly and after a few months hospitalization is no longer required This can be accomplished by transurethral operation Many months must elapse, however, before any surgical procedure of this sort is attempted to restore micturition Some patients will have spontaneous recovery of function which is satisfactory But in the patients who are entirely unable to micturate after maximal recovery of neural function has taken place, a properly performed transurethral resection of the vesical neck will restore voluntary control of vesical function

⁹ Thompson, G J Cord Bladder Restoration of Function by Transurethral Operation, U S Nav M Bull 45 207-214 (Aug) 1945

Transurethral resection of the vesical neck does not cure the nerve lesion, neither does it restore the bladder musculature to normal, but it does enable the patient to micturate and to be continent

The ability to micturate or the lack of it depends on the balance between the retention mechanism, provided by bladder neck and urethral musculature, and the emptying mechanism, consisting in involuntary detrusor urinae muscle tone combined with the voluntary power exerted by the abdominal muscles and diaphragm. Cystoscopic examination in these cases, if it is made a number of months after injury, will reveal that the previously flaccid bladder wall has changed to detrusor muscle fibers, which are definitely hypertrophied. Trabeculation and sometimes cellule formation will be noted. Even though the vesical neck appears relaxed, it will be evident on careful examination that the muscle bundles which surround the vesical neck are also thickened. This is especially noticeable on critical examination when the bladder is distended.

In some instances a prominent contraction ring is apparent. It would seem highly probable that the contraction or stiffening of the musculature at the outlet prevents emptying of the bladder.

When a transurethral resection is performed, it is important to remove a substantial amount of tissue. The resection of a few pieces from the posterior half of the vesical neck usually accomplishes nothing, as a rule, tissue must be excised from the entire circumference of the outlet. Only in this way can the resistance of the retention mechanism be diminished sufficiently so that an increase of pressure within the abdomen, accomplished by straining, will squeeze the bladder dry.

The most gratifying feature of all is that between periods of micturition the patients have perfect control. Depending on fluid intake, four or more hours may elapse between periods of micturition.

Fistula—Wilhelm's¹⁰ experience indicates that rectourinary fistulas caused by trauma or acute inflammation often heal with conservative treatment. On the other hand, those due to tuberculosis or neoplasm offer a grave prognosis. Short traumatic fistulas of large diameter are apt to persist and to require radical operative repair. These chronic rectovesical and rectourethral fistulas are usually best approached by the perineal route. Fecal diversion is valuable as palliative treatment and may occasionally be followed by spontaneous closure of a fistula. However, the preoperative administration of succinylsulfathiazole has enabled us to dispense with colostomy preliminary to radical repair. In 9 of the 13 cases of rectourinary fistula, the patients were cured, in another case, the patient was greatly improved.

¹⁰ Wilhelm, S. F. Treatment of Recto-Urethral and Recto-Vesical Fistula, *J. Urol.* **53** 719-722 (May) 1945.

Carcinoma—Hayes and Segal¹¹ considered mucinous carcinoma of the urachus, which invades the bladder, and they reviewed 44 cases collected from the literature and reported 1 case which they had observed. The majority of the patients were men, and all were in the middle and later periods of life. The youngest patient was a man 26 years old. In all but 1 of the reported cases, the neoplasm had eroded through the vesical mucosa. Cystoscopy revealed either a fungating ulcer or a papillary mass of varying size at the vault of the bladder.

In the case which they reported, the patient was a man, aged 65 years, who complained of pain in the lower part of the back and painless hematuria. Cystoscopy revealed a papillomatous growth in the fundus of the bladder, a part of which was resected with the McCarthy resectoscope. Two weeks later, the bladder was opened and the mass, which was found to be attached to the peritoneum, was removed. The diagnosis was adenocarcinoma of the urachus, which had perforated the urinary bladder.

Ulcer—In the investigation of the lymphatics of the bladder, Powell¹² was impressed by the similarity of the microscopic picture of progressive chronic lymphatic edema and the classic histologic description of Hunner's ulcer.

The author successfully injected the lymphatics of the bladders in 24 infant cadavers. From this study he concluded that there was a bottleneck of the lymphatics coming from the dome of the bladder. Powell stated that lymphatic blockage was possible in the female but not likely in the male. Should blockage ensue, a lymphedema of the mobile portion of the bladder would be expected and a physiologic vicious cycle put into action, in which edema, spasm and nutritional disturbance at the surface of mucosa would inevitably follow, as is known to occur in Hunner's ulcer. The author outlined possibilities of the lymphatic block as follows:

- 1 Blockage of a large number of lymph nodes by infection
 - a. Pelvic inflammatory disease now or at some time in the past (specific or nonspecific)
 - b. Various types of inflammation as a result of normal or abnormal parturition, abortion, ovarian disease, chronic cervicitis, etc.
 - c. Infections in the cul-de-sac, retroperitoneal from perinephritis, etc., peritonitis and proctitis [lymphopathia venerea]
- 2 Interruption of lymph circulation by tumors, such as fibroids and other pelvic surgical diseases

11 Hayes, J. J., and Segal, A. D. Mucinous Carcinoma of the Urachus Invading the Bladder, *J. Urol.* **53** 659-669 (May) 1945.

12 Powell, T. O. Studies on the Etiology of Hunner Ulcer. *J. Urol.* **53** 823-835 (June) 1945.

- 3 Surgical interruption of collectors during pelvic operations
- 4 Blockage of anterior horizontal collectors
 - a By infection as a result of cervicitis, giving rise to supravescical fibrosis
 - b By possible pressure from uterus against pubic bone, interrupting rare type of main collector on the anterior wall of bladder

On reviewing all the reported cases in the literature, the author concluded that careful evaluation revealed that the majority of patients suffer or have suffered from gynecologic disease or a disease process in the region of the rectum or that they have undergone some operation on the pelvis or lower part of the abdomen

Powell further stated that the histologic sections of dogs' bladders with partial lymphatic obstruction were not unlike those in the majority of reported cases of elusive ulcer. The pathologic process can be better appreciated grossly at the time of operation than later, when the tissues are fixed and shrunken. The history in most instances indicates a chronic process over a long period, averaging five to ten years. Probably the majority of patients with the same early history overcome their lymphatic disturbance and recover. Only in the rare case in which several mechanisms come into play does the blockage cause Hunner's ulcer.

Incrustation—Lins¹³ described a primitive method of dissolving the skeleton of the Candiru, which permeates the urethras and bladders of bathers in the Amazon. This remedy is the butach apple made into a brew and drunk hot. A synthetic formula similar to the brew from the butach apple was given, this consists of methenamine 10 Gm, proteolytic enzyme (pepsin) 1 Gm, citric acid 32 Gm, tannic acid 10 Gm, magnesium oxide 4 Gm, sodium carbonate 4 Gm and water 1,000 cc. In 12 cases of vesical incrustation and alkaline cystitis in which this formula was employed, all the calcareous material in the bladder disappeared.

Herger and Sauer¹⁴ stated that their investigations as to the usefulness of the stone-dissolving agent known as solution G (a solution of citric acid, magnesium oxide and sodium carbonate of p_H 4) have indicated that it is a valuable adjunct in the treatment of persistent alkaline infections of the urinary tract. It is of particular value in cases in which a tendency toward formation of stones and incrustation is predominant. In none of the 41 patients treated has the use of solution G produced ill effects of appreciable importance, and it was tolerated by all patients who were able to tolerate an indwelling catheter.

13 Lins, E. E. The Solution of Incrustations in the Urinary Bladder by a New Method, *J. Urol.* **53** 702-709 (May) 1945.

14 Herger, C. C., and Sauer, H. R. Treatment of Alkaline Incrustations of the Urinary Tract with Solution G, *J. Urol.* **53** 696-701 (May) 1945.

The results accomplished were most impressive in cases of incrustated alkaline cystitis and in cases of incrustated radium necrosis. Owing to its ability to dissolve calcareous deposits consisting of alkaline phosphates, it is considerably superior to other methods heretofore employed in the treatment of these conditions. The experience of Herger and Sauer has shown that in the majority of cases one course of treatment, lasting from two to four weeks, has been sufficient to produce lasting results, however, in certain cases it will be necessary to repeat treatment if manifestations of recurrent disease develop.

As to the value of solution G as a stone-dissolving agent, they found that it was indicated under certain conditions only.

Solution G has proved valuable in cases in which formation of stones in the kidney occurs as a result of infection with urea-splitting bacteria. Heretofore, surgical removal of these concretions was the only alternative. By the use of solution G, it is within the realm of possibility to dissolve these stones before they become hard or before they attain large size. If surgical removal of stones from badly infected kidneys is carried out, nephrostomy should be done routinely in order to facilitate postoperative irrigation with solution G. Also, in cases of sandlike deposits or multiple calculi in the renal pelvis in which complete removal of concretions is impossible without severely injuring the kidney, Herger and Sauer advocated the use of solution G postoperatively for a dual purpose, namely, to dissolve the remaining stones and to prevent formation of new stones.

The indication for use of solution G for the purpose of dissolving vesical stones is a limited one. Since many of the patients require elimination of some form of obstruction, surgical procedures are preferable to a tedious and time-consuming attempt at dissolution of the calculi. Even in cases in which there is no evidence of obstruction, litholapaxy or removal of small stones with the aid of the rongeur is a much simpler procedure. However, the use of solution G should be advocated under certain conditions, namely, in the cases of alkaline vesical stones in which the patients refuse operation or transurethral manipulation, in cases in which such procedures are contraindicated for various reasons and in cases in which the bladder is so badly infected that treatment of the infection is desirable before attempts at removal of vesical stones are made.

PROSTATE GLAND

Hypertrophy—Nesbit¹⁵ made an evaluation of clinical data in 176 cases of "large" prostate glands treated by transurethral resection at the University Hospital of the University of Michigan Medical School.

15 Nesbit, R. M. Transurethral Resection for Prostatic Hypertrophies of Large Size, Surg., Gynec. & Obst. **81** 515-520 (Nov.) 1945.

This study disclosed that the size of the gland was not a determining factor influencing the morbidity, mortality or length of stay in the hospital. Comparison of data in this group of cases with those of all cases of benign hypertrophy revealed that the loss of blood is greater when the large glands are resected and, as a result, postoperative transfusions are more often required, also, that external urethrotomy is done more often in this group of cases (33.5 per cent) than in all cases of resection (20 per cent).

The end results following transurethral resection in this group of cases are excellent, in only 1 case was the result regarded as poor. The end results in cases in which more than 80 Gm of tissue were removed were just as good as those in the other cases in this group, and these facts support the impression that has long prevailed among experienced resectionists, namely, that patients with large prostate glands obtain just as good results following a proper resection as do patients having smaller prostates and that the end result following transurethral resection is determined not by the size of the prostate but rather by the adequacy of its removal.

Bassow¹⁶ reported a case in which progressive gangrene of the skin followed suprapubic prostatectomy. He stated that this condition is a rare postoperative complication. Its cause is not clear. It may occur in the young patient as well as in the old one. Surgical technic does not appear to be an etiologic factor. Physical debility is of questionable significance when one considers the large number of elderly debilitated persons who undergo operation and who apparently escape this particular surgical complication.

That this complication is even less frequent in urologic surgical treatment than in general operation may perhaps be explained by the increased use of the transurethral approach to the obstructing prostate and the less frequent use of the suprapubic technic. Furthermore, prostatism, which is an insidious symptom complex, may stimulate an appreciable resistance to the infectious organisms, which are ever present in large numbers.

The case reported by the author was studied in retrospect only. Had the lesion been identified earlier and had more radical treatment been instituted, death might have been averted. The clinical appearance of the lesion, the symptom complex associated with the disease, such as excruciating local pain, the absence of systemic reactions and the cultural identification of the two organisms acting in a symbiotic arrangement removed all doubt as to the correct classification of the lesion.

16 Bassow, S. H. Postoperative Progressive Gangrene of the Skin Following Suprapubic Prostatectomy, *J. Urol.* **54**: 46-52 (July) 1945.

Hey¹⁷ discussed the principles of aseptic suprapubic total prostatectomy. It was suggested that postoperative uremia is due to infection and is encouraged by any method of slow decompression, open drainage or instrumentation. Slow decompression in chronic obstruction is unnecessary. The importance of avoiding a septic procedure and of not leaving a permanently infected urinary tract in an old man was stressed. "Aseptic prostatectomy" should reduce the over-all mortality by at least 80 per cent.

Carcinoma—Nicholson¹⁸ reported a case of carcinoma of the prostate in which the patient was 15 years old. He had had difficult micturition and retention of urine. Rectal examination with the bladder empty disclosed a hard, nodular prostate. An intravenous urogram showed bilateral hydronephrosis. A plain roentgenogram of the abdomen and pelvis disclosed nothing abnormal. A suprapubic cystostomy was done and a mass about the size of a tennis ball was found in the region of the prostate. It was nodular and hard. The patient died the following day.

Gardiner and Cummins discussed a similar case, in which the duration of symptoms was even shorter, the patient died seven weeks after the onset of symptoms.

PENIS

Anomalies—Blanco¹⁹ reported a case of diphallus, or double penis. The two organs had a common covering on their posterior parts but were completely independent and free anteriorly. The upper and normally developed penis was functionally perfect, while the lower and smaller one acted as a supernumerary penis and had no function whatever. Although each penis appeared to have its individual urethra, it could not be determined whether there was a union between them or whether there were two completely independent urethras communicating with a common bladder. With the exception of a divided scrotum, no other anomalies were found either in the genitourinary tract or elsewhere in the body. It is unfortunate that, owing to lack of cooperation on the part of the patient, Blanco was unable to present a complete study of this interesting case.

URETHRA

Glandular Structure—Folsom and O'Brien²⁰ said that the posterior part of the female urethra is surrounded by a definite group of glands which are identical with the prostate gland in shape, distribution,

17 Hey, W. H. Asepsis in Prostatectomy, *Brit J Surg* **33** 41-46 (July) 1945

18 Nicholson, N. J. Carcinoma of the Prostate in a Youth *Brit J Surg* **32** 533-534 (April) 1945

19 Blanco, S. Diphallus (Double Penis), *J Urol* **53** 786-790 (June) 1945

20 Folsom, A. I., and O'Brien, H. A. The Female Urethra. The Connecting Link Between the Urologists and the Gynecologists, *J A M A* **128** 408-413 (June 9) 1945

secretory activity and site. These glands may become infected in early infancy and may remain infected for many years or even throughout life. Such infection may produce a varied and at times a bizarre papillary posterior urethritis. This inflammatory urethritis may vary from a mild granular urethritis to a more definite papillary urethritis.

In many cases the urethral lumen is definitely narrowed and the stricture is part of the pathologic picture.

There are two groups of clinical symptoms that are produced by this inflammatory posterior urethritis, namely, vesical irritation and pain. Many women suffer for years from either a continuous or a frequently recurring vesical irritation characterized by urinary frequency and burning. These symptoms vary widely in different cases, some women are merely annoyed by occasional attacks of a mild degree, while others may have almost a constant urinary frequency and burning. At least 90 per cent of the women who have a urologic disease have this vesical irritation as one of the presenting symptoms if not the main one. In 90 per cent of this group an inflammatory urethritis is the cause of this troublesome symptom. In spite of this, the urine is usually free from pus.

Another symptom of this inflammatory posterior urethritis is pain. The pain is referred to various sites. As a rule it is dull and aching in character, but at times it may be similar to renal colic in its site and severity.

The most frequent sites of this referred pain are the lower part of the iliac region, the lumbosacral region, the loin and the inner side of the thigh. If the pain is severe and situated in the loin, it may be mistaken for the pain of renal or ureteral disorder.

Urethral dilation should be performed regularly twice a week. At first, one should use a sound that will stretch but not tear the urethral mucosa. Then the size of the sound should be gradually increased until a 30 or 32 F. can be inserted easily. After each dilatation, 10 to 15 cc. of a 0.25 per cent solution of strong protein silver should be instilled into the urethra. When the urethra has been dilated for about six weeks, one should fulgurate some of the pathologic tissue in the posterior urethra. The patient then should be allowed to rest for two weeks. Then performance of dilation should be resumed for from six weeks to two months, at the end of this period, fulguration should be repeated. This routine should be continued until the patient is relieved and there is no further evidence of pathologic change in the posterior urethra.

Diverticula—Higgins and Rambousek,²¹ in discussing diverticula of the female urethra, stated that the classification of any diverticulum as

21 Higgins, C. C., and Rambousek, E. S. Diverticula of the Urethra in Women. Review of Twelve Cases, *J. Urol.* 53: 732-738 (May) 1945.

acquired or congenital is modified by the duration of symptoms, method of onset, age of the patient and histologic character of the lesion. Congenital diverticula are apparently rare, a review of the literature reveals only 2 cases of this type. The lesion probably results from infection of the urethral glands, with sealing of their openings into the urethra. An abscess develops and ruptures into the urethra, reestablishing the communication. This appears to have been the sequence in all but 1 of the 12 cases reported by these authors. Acquired diverticulum may be secondary to urethral stricture or stone, or it may follow instrumentation of the urethra. It is frequently asserted that trauma sustained by the urethra during childbirth may produce a diverticulum.

The symptoms may be localized or referred to the urinary tract. When the symptoms are localized, the patient may complain of pain, a tender mass, dyspareunia and recurrent discharge of pus from the urethra, which is followed by relief. The three commonest symptoms in the case reported by Higgins and Rambousek were dysuria, discharge of pus from the urethra, with relief of symptoms, and the presence of a palpable mass.

The diagnosis should be considered whenever women complain of symptoms in the lower part of the urinary tract, particularly of recurrent attacks of cystitis for which there is no other explanation. When the patient complains of a mass in the region of the urethra, which may be tender and painful to touch, diverticulum should always be suspected, especially when the symptoms subside after discharge of pus from the urethra. The expression of purulent material from the urethra by digital pressure through the vagina over the painful mass is practically pathognomonic. The diagnosis is established by careful palpation of the urethra, urethroscopic examination and urethrography.

Most urethral diverticula have thick fibrous walls and show evidence of chronic inflammation. In 16 of 24 reported cases, the lining membrane consisted of squamous, columnar, cuboidal, transitional and stratified squamous epithelial cells. In the other 8 cases, a lining membrane was absent but the inner surface of the sac consisted of granulation and fibrous tissue.

Higgins and Rambousek reported 12 cases of urethral diverticula observed at the Cleveland clinic. In all but 1 of the cases the diverticula were obviously of the acquired type, since they occurred in women between the ages of 38 and 66 years. The duration of symptoms ranged from five months to eleven years. All but 2 of the patients gave a history of recurrent attacks of cystitis, and all had painful masses in the region of the urethra at some time during their illness. Five of the patients were completely cured by excision of the diverticulum. In 1 case, incision and drainage of the infected diverticulum produced satisfactory results. Two patients responded satisfactorily to drainage of

the diverticulum by frequent digital pressure and urethral dilation. In 2 instances treatment was not recommended, as the patient had no symptoms referable to the diverticulum. A postoperative urethrovaginal fistula developed in 2 of the 5 cases in which the diverticulum was excised. In 1 of these cases, the fistula was closed and the patient remained asymptomatic. In the other case, a minute fistula was noted at examination three years after the excision, although the patient was unaware of its presence.

McNally,²² in discussing diverticula of the urethra, stated that he had observed 5 cases and had collected 6 more from hospital records. In 9 of the 11 cases there was a history of a suburethral abscess, and in 2 of these cases the patients were first seen when the abscess was present and later were seen again when the diverticulum was present. The diagnosis is simple if one considers and remembers the fact that a diverticulum can be present.

McNally found no case in which symptoms were absent, and he expressed the opinion that the diverticulum should be excised. Excision has been a fairly simple procedure in his hands. He uses a prostatic retractor to retract the urethra. The vaginal incision is made to one side of the diverticulum, the diverticulum is excised and the sac is transfixated and ligated. Some tissue is brought over the neck of the sac, and the vaginal incision is closed to one side, so that the incisions are staggered. McNally has not observed a urethrovaginal fistula in any of his cases.

Downer and Virgilio²³ reviewed the literature on diverticulum of the female urethra and reported a case which they had observed. This urologic entity would become commoner than one is led to believe if every case that came under observation would be reported. Exact statistics as to the frequency of this lesion are not available. In the vast majority of the cases the lesion is acquired from either inflammatory processes or trauma. The literature contains reports of cases in which the lesion has been believed to be congenital. Downer and Virgilio reported a case in which the lesion was acquired and of infectious origin. Diagnosis is not difficult if the condition is borne in mind. It may be made absolute by urethroscopy and urethrography. Excision of the sac is the treatment of choice and results in prompt relief of symptoms.

Carcinoma—Hess²⁴ stated that cancer of the female urethra is a preventable disease if granular urethritis is recognized and treated. All

22 McNally, A., in discussion on Higgins and Rambousek,²¹ p. 739.

23 Downer, I. G., and Virgilio, F. D. Diverticulum of the Female Urethra. Review of Literature with Case Report, *J. Urol.* **54**: 53-58 (July) 1945.

24 Hess, E. Primary Carcinoma of the Female Urethra, with Especial Reference to the Lesion Known as Urethral Caruncle, *Pennsylvania M. J.* **48**: 1150-1155 (Aug.) 1945.

hyperplastic lesions of the mucosa of the female urethra must be considered malignant until proved otherwise by biopsy. The majority of these conditions—mucosal hypertrophy with eversion, external and internal caruncle and the suspected malignant lesion—usually affect women who are between 40 and 70 years and who have had genital infection for a long time. The percentage of cases in which these hyperplastic lesions become malignant is much larger than ordinarily considered, that is, approximately 33 per cent. Involvement of the lymph nodes which usually occurs late in the course of the disease, is a bad prognostic sign. In cases in which there is extensive infiltration of the anterior wall of the vagina, the author transplants the ureters into the skin or intestine. This procedure is followed by total cystectomy and the removal of a large portion of the anterior wall of the vagina.

CHEMOTHERAPY

Penicillin—Nolan²⁵ stated that penicillin is an addition to other types of urologic treatment and not a substitute for any recognized surgical procedure. Used alone or in conjunction with surgical treatment, it is a most important addition that will result in a reduction in mortality and morbidity. Its field of use is limited to cases in which the organisms are specifically sensitive to it, and it will even then not affect those organisms if it cannot reach them because of the presence of foreign bodies, necrotic material, avascular tissues or lack of drainage.

Because of the high concentration in the urine, the prolonged use of penicillin may be indicated in cases in which infection is due to some organism that is not particularly sensitive to this substance. The optimal time-dose ratio must be based on the sensitivity of the organism and on the severity and site of the infection. Penicillin, like the sulfonamide drugs, should be administered in relatively large doses initially, so that the micro-organisms have no chance to become resistant. The minimal degree of toxicity renders this course harmless. Penicillin is much better tolerated than are the sulfonamide compounds.

Staphylococci require, as a rule, much larger doses of penicillin than do susceptible strains of streptococci. Nolan advocated large initial doses, with proper time ratio, to prevent the organisms from becoming resistant to penicillin. In cases of severe staphylococcic infection, a total dose of between 1,000,000 and 3,000,000 units should be administered and the treatment should be continued from ten days to two weeks to produce maximal therapeutic results.

After a study of the oral administration of penicillin with various enteric coatings and adjuvants to protect the penicillin or promote its

25 Nolan, O. F. Treatment of Genito-Urinary Tract Infections with Penicillin, *J. Urol.* 53 817-822 (June) 1945.

absorption, Cutting, Halpern, Sultan, Armstrong and Collins²⁶ recommended the following useful combinations mixtures of penicillin with trisopropanolamine, trisodium citrate or sodium carbonate enclosed in a resin-cellulose plastic enteric coating

When a dose of 50,000 units of penicillin was administered every two hours until ten doses had been given, these combinations produced concentration of from 0.02 to 0.05 units of penicillin per cubic centimeter of blood. Fifty-three patients who had acute gonorrhea were treated with several of the most promising combinations. A cure was obtained in 38, or 72 per cent, of the 53 cases. Oral administration of penicillin appears practicable in cases of infection with bacteria that are highly susceptible to this substance.

Romansky, Murphy and Rittman²⁷ reported a series of 175 cases of gonorrhea in which the patients, who were men, were treated by a single injection of calcium penicillin in a mixture of yellow wax and arachis (peanut) oil. The results were satisfactory in all the 75 cases in which a single injection of 150,000 units was employed. Ninety-three of the 100 patients who received single injections of 100,000 units were cured. The remaining 7 responded to a second single injection of 150,000 units of penicillin in the mixture of yellow wax and arachis oil.

A single injection of 100,000 to 150,000 units of calcium penicillin in yellow wax and arachis oil will produce and maintain essayable levels of penicillin in the blood for seven and a half to ten hours, and excretion of penicillin in the urine will continue for twenty-four to thirty-two hours.

The administration of penicillin in a mixture of yellow wax and arachis oil has not produced any abnormal reactions either locally or constitutionally.

Cohen and Grover²⁸ studied several plans of administering penicillin to ambulatory patients and reported their results. A single intramuscular injection of 100,000 units of penicillin in aqueous solution is not efficacious in the treatment of gonorrhea in men. It produced a cure in only 41.4 per cent of the cases in which it was used. Divided doses of penicillin are more effective than single large doses, provided the time interval between doses is neither too long nor too short. In cases in which treatment has not been employed previously, the addition of

26 Cutting, W. C., Halpern, R. M., Sultan, E. H., Armstrong, C. D., and Collins, C. L. Administration of Penicillin by Mouth, with Results in the Treatment of Gonorrhea, *J. A. M. A.* **129**:425-432 (Oct. 6) 1945.

27 Romansky, M. J., Murphy, R. J., and Rittman, G. E. Single Injection Treatment of Gonorrhea with Penicillin in Beeswax-Peanut Oil. Results in 175 Cases, *J. A. M. A.* **128**:404-407 (June 9) 1945.

28 Cohen, D. L., and Grover, M. L. Ambulatory (Duty Status) Sodium Penicillin Therapy of Gonorrhea in the Male, *J. Urol.* **53**:812-816 (June) 1945.

sulfathiazole to penicillin will increase the percentage of cures obtained. Sulfonamide-resistant gonorrhea also shows a tendency to be resistant to penicillin. Beyond a certain point, probably about 50,000 units, an increase in the size of a single dose rapidly invokes the law of diminishing returns. It is believed that in the not too distant future "penicillin-resistant" gonorrhea, analogous to "sulfonamide-resistant" gonorrhea, will be encountered. Local penicillin therapy by means of intraurethral instillation for periods of one hour is of no value in the treatment of gonorrhea.

Koch, Haines and Hollingsworth²⁹ made a study of the value of penicillin in the treatment and control of gonorrhea. Of 485 patients treated with an initial course of 200,000 units, 68 (14 per cent) were not cured. Hospitalization of patients with gonorrhea does not appear to affect the rate of failure. This would indicate that failures occurring in outpatients are probably not reinfections. Minimal criteria of cure, including multiple cultures in penicillin-treated patients with gonorrhea, are indispensable to the public health control of the disease.

The authors found no case of complete penicillin resistance, however, in 1 of 7 cases the result of the first course of treatment was a failure. In many cases more than two courses were required, and in some of the cases sulfonamide drugs and pyrotherapy were administered simultaneously.

The authors were unable to confirm the necessity for the usually accepted practice of differentiating gonococci and other members of the *Neisseria* family by sugar fermentation tests, three hundred and fifty laboratory observations, although not conclusive evidence, constitute a considerable group on which to base an opinion.

In the control of gonorrhea, the medical profession must be aware of the limitations of penicillin therapy, the possibility of producing a carrier state and the social factors related to the spread of the disease.

Sulfonamide Drugs—Lehr³⁰ made a comparative study of the acute and chronic toxicity of the sodium salts of sulfacetimide, sulfadiazine and sulfanilamide by administering these drugs intraperitoneally to albino rats.

Figured on the basis of the median lethal dose (LD_{50}), sodium sulfacetimide possesses by far the lowest acute toxicity, being about five times less toxic than sodium sulfadiazine and more than seventeen times less toxic than sodium sulfanilamide. Based on mean values

29 Koch, R. A., Haines, J. S., and Hollingsworth, W. Y. Evaluation of Penicillin in Gonorrhea Treatment and Control, *J. A. M. A.* **129** 491-495 (Oct. 13) 1945.

30 Lehr, D. Experimental and Clinical Studies with Sulfacetimide (p-Aminobenzenesulfonylecetimidate). Toxicity and Efficiency in Bacillary Infections of the Urinary Tract, I. Experimental Studies, *J. Urol.* **54** 87-105 (July) 1945.

of the highest concentration of these drugs in the blood after the administration of fatal doses of the three sulfonamide drugs, the relationship of the acute toxicity of sulfacetimide, sulfadiazine and sulfanilamide is as 1 2 10

The chronic toxicity of sodium sulfacetimide is likewise by far lower than the toxicity of sodium sulfadiazine. When a daily dose of 0.6 Gm per kilogram of body weight was administered for nine weeks, sulfacetimide caused no significant pathologic lesions. The equimolar amount of sulfadiazine (0.7 Gm per kilogram), however, invariably produced severe organic damage, particularly in the kidneys and, in many instances, also in the aorta.

The low renal toxicity of sulfacetimide was explained as due to its high solubility (in water, sulfacetimide is about one hundred and fifteen times as soluble as sulfadiazine), which apparently precluded the serious consequences of massive and long-lasting intratubular deposition of crystals which occurred when sulfadiazine was used.

The ready absorption and rapid renal elimination of sulfacetimide as well as its high solubility, particularly in urine, made it possible to obtain high concentrations of the drug in the urine in the presence of relatively low concentrations in the blood.

In *in vitro* antibacterial experiments, it was found that sulfacetimide exerted a powerful effect against *Escherichia coli*, even if extremely large inoculums were used.

The results of these experiments suggest that from a pharmacologic and toxicologic standpoint sulfacetimide deserves preference over other sulfonamide drugs now in use for the treatment of infections of the urinary tract.

FILARIASIS

McMartin³¹ stated that filariasis has infected thousands of men in our armed forces in the Pacific Area. The disease in these men is characterized by episodes of lymphangitis and lymphadenitis. The majority of the patients have genital (scrotal) involvement. Civilian urologists will be confronted with the problems of differential diagnosis of intrascrotal pathologic changes caused by filariasis as well as intrascrotal pathologic changes usually encountered in the United States. There are many members of our armed forces who have filariasis and fear the onset of elephantiasis despite attempts of medical officers to dispel their fears. One can do a great deal to ease the minds of these patients by educating them on the characteristics of the disease.

There is no specific drug in the treatment of filariasis. Removal of the patient to a temperate climate and away from the chance of additional

31 McMartin, W. J. Urological Aspects of Filariasis, *J Urol* 54 62-74 (July) 1945

infection is most important. Rest, elevation of the affected parts and cold applications are the treatment of choice in episodes of exacerbations of the disease. Research on the treatment of filariasis is constantly being carried out by competent medical personnel of the Army and Navy. Excellent results of this work soon may be reported in the literature. Much will be added to the knowledge of the pathologic changes of early filariasis when and if complete postmortem examinations can be done on patients who have filariasis or who have a history of having had filariasis at some time during their life.

Filariasis will not become a public health problem in the United States. Permanent disability as a result of filarial infestation among our armed forces will be a rarity. The Army and Navy Medical Corps have progressed rapidly toward eradication of this disease.

URINARY OBSTRUCTION

Urinary obstruction³² involving most frequently the upper part of the ureter, the neck of the bladder and the urethra is a common lesion among the Army personnel. The acquired prostatic lesions of old age are uncommon, as might be expected. The majority of these lesions have existed prior to the patients' induction. Narrowing of the vesical outlet owing to fibrosis or muscular hypertrophy is frequently seen. The contracture may be a superficial sclerosis of the vesical neck without adnexal involvement or it may be deep seated from long-standing associated chronic posterior urethritis and prostatovesiculitis.

These contractures may be separated clinically into three groups, depending on the degree of sclerosis and obstruction. Group 1 includes vesical irritation, characterized by increased frequency of micturition, urinary urgency or nocturia and clear urine. Group 2 includes the stage of residual urine, with signs of obstructive uropathy in the bladder, such as trabeculation and hypertrophy of the trigone; there is diminution in size and force of the urinary stream and there may be associated sexual symptoms, such as premature ejaculations, persistent erections from posterior urethral irritation and sexual neurasthenia. During acute exacerbations, the urinary symptoms become more pronounced and there may be associated suprapubic and perineal discomfort, backache, renal colic or hematuria. Group 3, or the third stage, includes more advanced retention, with increasing inability to void, associated with periods of acute complete retention.

Careful routine urologic examination will permit one to make the diagnosis. Cystoscopy shows a deep urethral, vesical neck, changes

³² Riba, L. W. and Schmidlapp, C. I. Surgical Treatment of Urinary Obstruction in Army General Hospital Surg. Gynec. & Obst. **80** 368-372 (April) 1945.

in the trigone and vesical wall and elevation of the posterior vesical lip, with a characteristic deformity of the vesical outlet. Rectal palpation of the vesical neck while the instrument is in place in the urethra will show the degree of thickening of the posterior commissure. Cystourethrograms are valuable in demonstrating constriction of the vesical neck and associated changes in the bladder. When symptoms of vesical irritability are relieved temporarily after cystoscopic examination, a contracture should be suspected.

In cases of a mild degree of obstruction, treatment should be conservative and should include rest in bed, sedatives, heat and dilatation of the vesical neck. After the obstruction has reached the second stage, that of residual urine or retention, transurethral resection is indicated. Palliative treatment produces only temporary relief. Varying amounts of tissue have to be removed, from 5 to 20 Gm., depending on the depth and the degree of the obstruction.

Obstruction at the ureteropelvic junction is the commonest lesion of the upper part of the ureter and produces varying degrees of hydronephrosis. This lesion is congenital and usually is silent until infection or calculi or both have developed. Treatment is primarily surgical, and the well known principles regarding the selection of patients for operation and the type of surgical repair at the ureteropelvic junction are employed.

Urethral strictures were found in 12 per cent of the patients admitted to the genitourinary service of a large Army hospital. Strictures of wide caliber, that is, larger than 20 F., are usually asymptomatic, except for the slight morning drop, mild pyuria and shreds in the first glass of urine. They frequently respond to a repeated urethral dilation. The small caliber of multiple anterior urethral strictures presents more of a problem of treatment from the military standpoint. Such strictures usually occur in a soldier who has had repeated gonorrheal infection and a recurrent urethral discharge. There are usually an associated prostatovesiculitis and chronic or recurrent epididymitis. When acute gonorrhea or trichomonas infestation is superimposed on severe strictures, the infection usually is resistant to sulfonamide drugs and penicillin. In strictures of small caliber, progressive urethral dilation is indicated or if they are fibrous and resilient and respond poorly to dilation internal urethrotomy should be performed, preferably electro-urethrotomy.

If in maladjusted or inadequate service patients the lesions existed prior to induction operation should not be performed unless emergency treatment is necessary. Operation performed on a soldier who cannot be rehabilitated may facilitate later pension claims.

Intrinsic ureteral strictures were found to exist in 2 per cent of a large series of cases in which urologic examination was performed.

These strictures were relatively asymptomatic until sufficient obstruction developed to invite infection. Care must be taken in interpretation of the ureterograms, for ureteral blockage to a catheter, nonopaque calculi, mucosal pockets, lateral angulation or spasm are frequently erroneously diagnosed as a stricture. Intrinsic neuromuscular dysfunction and ureteral dilatation resulting from chronic infection frequently suggest stricture on pyelography. In such cases, ureteral calibration is of value and will rule out the presence of an intrinsic stricture. The treatment is progressive ureteral dilation and the clearing-up of any coexisting infection.

In general, it may be said that in the Army there is ample opportunity to apply principles of recognized conservative measures in the treatment of urinary obstruction, which usually affects younger men. These procedures not only will rehabilitate the patients during the emergency but will in a great measure add to their health and happiness after their discharge from the service.

ENURESIS

Forsythe and Karlan³³ stated that in cases of enuresis examination should include careful neurologic and laboratory study and complete urologic examination. A cystometric study should be a routine procedure. In 13 of 25 cases studied, the enuresis was due to local uropathy, in 9 cases the patients had an uninhibited neurogenic bladder. In only 3 cases did the enuresis appear to be functional. Minor corrective urologic procedures often eliminate enuresis of long duration. The authors concluded that in most cases in which the patients are adults the enuresis probably is not functional in origin.

HEMOSPERMIA

Acute hemospermia is not uncommon, and the causes are often obvious, such as prostatitis and infection of the posterior urethra, vesical outlet and seminal vesicles. It also may be present in ejaculations following trauma or before there is complete healing following prostatic resection. Huggins and McDonald³⁴ consider hemospermia to be chronic if it persists for more than a month and if an obvious cause cannot be found.

In the past year they observed 9 cases of hemospermia. In 2 of the cases, symptoms had been present less than two weeks and disappeared spontaneously. In 5 of the cases, the semen had been bloody

33 Forsythe, W. E., Jr., and Karlan, S. C. Enuresis in Young Male Adults, *J Urol* 54 22-38 (July) 1945

34 Huggins, C., and McDonald, D. F. Chronic Hemospermia: Its Origin and Treatment with Estrogen, *I Clin Endocrinol* 5 226-231 (May-June) 1945

persistently for one year or more. In the 2 remaining cases the symptoms had been present for one month and five months respectively. Urologic examinations did not disclose any gross abnormalities except prostatitis, which was present in 1 case. The 7 cases were selected for study because the cause of the hemospermia was unknown and successive bloody ejaculations had been present for a long time.

Fractionated collections of the semen as ejaculated were made in three glasses, and when the volume was small the semen was collected in a single tube. Chemical study consisted in the determination of reducing substances and the amount of fibrinolysin and acid phosphate. Microscopic examination of the semen in each glass was done to determine motility and shape of the sperm, and erythrocyte and spermatozoa counts were made in a counting chamber.

Gross examination of the fractionated semen collected in three glasses showed little or no blood in the first glass and progressively greater amounts of blood in the second and third glasses. In the same way, the concentration of glucose, a component arising from the seminal vesicle, was found to be greatest in the third glass, whereas the concentration of the prostatic derivatives, fibrinolysin and acid phosphates, was greatest in the first glass.

No erythrocytes were found in normal semen, although leukocytes and epithelial cells were always observed in small numbers. In cases of hemospermia, erythrocytes were always present, both singly and in agglutinated clumps. Results of cystourethroscopic examination of the patients were uniformly negative. On the basis of these observations, it is certain that hemorrhage arose in the seminal vesicle in all these cases of chronic hemospermia.

Estrogen in the form of ethinyl estradiol was administered orally to 6 patients with chronic hemospermia in doses of 0.05 mg. three times a week to twice daily, depending on the response. Treatment was continued three to seven weeks except in 1 case, in which it was obviously ineffective. A low dosage of ethinyl estradiol caused complete cessation of hemorrhage in 5 of the 6 cases. One of the patients had a return of bleeding after three months.

The results of previous experimental observations coincided with the data obtained in the present study, namely, that relatively small doses of estrogen greatly depressed or eliminated the function of the seminal vesicles while the prostatic secretion, which predominated in the ejaculate, persisted, hence providing a measurable ejaculate.

The decreased volume of semen returned to normal after the administration of estrogen was discontinued, with the important difference that all the blood was absent. The depression of spermatogenesis by the estrogen was not permanent, and in each case spermatozoa of

normal shape appeared in normal numbers some weeks after treatment was discontinued

Quinland³⁵ made a study of 33 cases of urinary lithiasis in which the patients were Negroes. The ages of the patients ranged from 8 months to 69 years. Twenty-seven of the patients were males, and 6 were females. The site of the calculi was as follows: kidney in 13 cases, ureter in 4 cases, bladder in 15 cases and prostate gland in 1 case. The size of the calculi varied from renal sand to a large vesical calculus, which weighed 240 Gm. A ureteral calculus which measured 3.8 by 1.8 cm. was removed surgically, and the patient recovered. The causes of death in these cases were not wholly due to resultant complications, such as pyonephrosis, cystitis, peritonitis and septicemia, but to preëxisting diseases, such as carcinoma of the prostate, cardiorenal disease, hypertension with terminal apoplexy, bronchopneumonia, tuberculosis and diabetes mellitus. One patient died suddenly, presumably of embolism, seventeen days after operation.

ANTISPASMODICS

Prince and Richardson³⁶ used a new synthetic antispasmodic, AP-43 (3-[beta diethyl aminoethyl]-3-phenyl-2-benzofuranone hydrochloride) in a series of 61 cases in which spasm of the smooth muscle of the urinary tract was thought to be the major cause of pain. This drug has been found to be extremely effective in relieving pain resulting from ureteral catheterization and retrograde pyelography, and it aids in the passage of a substantial number of ureteral calculi when their size is not such as to preclude their spontaneous passage. In the same type of calculus, AP-43 will relieve pain in the great majority of cases. Apparently, unless the calculus causes pain, the drug is not effective in assisting the passage of the stone.

In 13 of 19 cases of severe vesical spasm, complete relief was obtained. It was suggested that AP-43 is of value when used in the following circumstances: prior to retrograde pyelography, to prevent postpyelogram pain; prior to cystoscopy, as an aid to ureteral catheterization, and prior to cystoscopic manipulation of ureteral calculi, to produce greater relaxation of the ureter.

Undesired side effects are uncommon and usually mild in nature when seen, there was no evidence of cumulative toxic effects in this series of cases. The drug may be given effectively either by mouth or intramuscularly. The trade name "Amethone" has been tentatively accepted for AP-43.

35 Quinland, W. S. Urinary Lithiasis. Review of Thirty-Three Cases in Negroes, *J Urol* **53** 791-804 (June) 1945.

36 Prince, C. L. and Richardson, E. I., Jr. AP-43. A New Antispasmodic for Use in Urology. *J Urol* **54** 75-86 (July) 1945.

SYPHILIS AND FERTILITY

Michelson³⁷ studied the fertility of 50 men who had syphilis. The characteristics of the semen, particularly of the spermatozoa, were employed in judging the degree of fertility in each case. A similar study of 50 nonsyphilitic men was made and the results compared with those in the cases of syphilis. It is evident that the fertility of this particular group of syphilitic men was equal to and compared favorably with that of the 50 nonsyphilitic men. It would appear that syphilis when correctly treated rarely affects the fertility of man.

³⁷ Michelson, L. A Study of Syphilis in the Male Relative to Fertility, *J Urol* **53** 808-811 (June) 1945

SIDESWIPE FRACTURES

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AND

MAJOR GEORGE S. PHALEN

MEDICAL CORPS, ARMY OF THE UNITED STATES

IN ANY large Army hospital, one sees traumatic injuries among soldiers not unlike those occurring in civil life. Owing to the total mechanization of our present day war machine, these injuries are usually much severer than those encountered among civilians. However, we have recently treated a group of patients who sustained severely fractured elbows in automobile accidents, and these injuries are exactly the same as those all too frequently seen among civilians. In view of this similarity of injuries occurring among both soldiers and civilians, we should like to call to the attention of the medical profession the so-called sideswipe fracture—a fracture fraught with complications, a fracture most difficult to treat and a fracture prone to produce a poor result.

The term "sideswipe" is applicable to this mutilating fracture of the left elbow, since it denotes the manner in which the fracture is sustained. The driver of an automobile has his left arm resting on the window frame, with his elbow projecting from the window, when his car is sideswiped by an oncoming vehicle or struck by some overhanging projection. Because of the mode of occurrence of this particular fracture, it has also been aptly termed a "car window elbow," a "driver's seat fracture" or a "traffic elbow."

After understanding the mode of occurrence, one can easily visualize the possibilities of the injury, which might well range from a few mere scratches to a most serious and disabling traumatic amputation. In most instances, however, a badly mutilated forearm and elbow result, with compound fractures of all the bones composing the elbow region as well as an avulsive loss of soft tissue and a tearing of the blood vessels and the nerves.

There has been little written on this subject in the medical literature. Shorbe¹ reported a series of 32 cases seen in the Oklahoma City Hospital, the majority of the patients were referred to him some time

¹ Shorbe H. B. Car Window Elbows, South M J 34 372-376 (April) 1941

following the original injury because of osteomyelitis or some other complication of the fracture Key and Conwell² briefly discussed the fracture on the basis of Shorbe's report Wood³ stated that in his experience amputation is resorted to in almost 50 per cent of these cases

We feel certain that if this fracture could be more widely publicized its occurrence could be largely prevented The sideswipe fractures which we have treated in the Army have occurred only while the soldiers were on furlough, leave or pass, none have occurred during actual maneuvers or in performance of regular duty This would lead one to believe that this particular injury is more of a civilian problem and, as such, should be recognized by the medical profession if for no other reason than their own self preservation and protection

REPORT OF CASES

Since July 1942, 7 patients with sideswipe fractures have been admitted to O'Reilly General Hospital, Springfield, Mo

CASE 1—On July 13, 1942, a 37 year old Army private was driving his car, with his left arm out of the drivers' window, when he was sideswiped by another car He sustained multiple avulsive wounds of the left forearm and hand as well as badly compounded, comminuted fractures of the middle third of the humerus, radius and ulna He was admitted to this general hospital approximately two hours later, in rather severe shock After initial treatment for shock, primary amputation through the humeral fracture site was performed because of the extensive wounds of the forearm and hand and the pronounced impairment of peripheral circulation The postoperative course was essentially uneventful After the amputation stump was healed, the patient was fitted with a prosthesis and subsequently discharged from the service.

CASE 2—On Sept 18, 1942, a 20 year old Army sergeant was driving his automobile with his left arm out of the driver's window, when he was sideswiped by another car He sustained a badly comminuted compound fracture of the distal end of the humerus and the olecranon process of the ulna and a simple fracture of the middle and distal third of the ulna He was immediately taken to an Army station hospital, where his wounds were débrided and primarily sutured, his fractures were manipulated and a plaster cast applied, with the elbow extended 60 degrees outside a right angle. Two days later he was transferred to this general hospital, where plaster immobilization was continued after several attempts at improving the position of the fragments Purulent drainage persisted from a sinus over the left elbow until Jan 3, 1943 The ulnar fractures healed in satisfactory alignment, but a pseudarthrosis through the humeral fracture site developed, permitting a range of motion in the left elbow of 60 degrees outside a right angle to 45 degrees inside a right angle (fig 1A and B) Rotation of the forearm was moderately limited He was returned to limited duty status after his discharge from the hospital on April 26, 1943

2 Key, J A, and Conwell, H E The Management of Fractures, Dislocations and Sprains, ed 3 St. Louis, C V Mosby Company, 1942, pp 629-633

3 Wood, C F Traffic Elbow, Kentucky M J 39 78-81 (Feb) 1941

CASE 3—On Oct 14, 1942, a 25 year old Army sergeant, while driving with his left elbow out of the driver's window, was sideswiped by a commercial bus, and sustained a compound fracture of the distal end of the humerus, extending into the elbow joint, and a compound fracture through the middle third of the radius and ulna. He was taken immediately to an Army station hospital, where his wounds were debrided, the fractures manipulated and a plaster cast applied from the axilla to the metacarpophalangeal joints, with the elbow flexed at 90 degrees. Subsequently, he was transferred to this general hospital, where plaster immobilization was continued until Jan 26, 1943. Physical therapy was then instituted. A definite nonunion persisted at the humeral fracture site. The patient was discharged to permanent limited duty status, working in a clerical position, with painless motion at the pseudarthrosis from 30 degrees outside a right

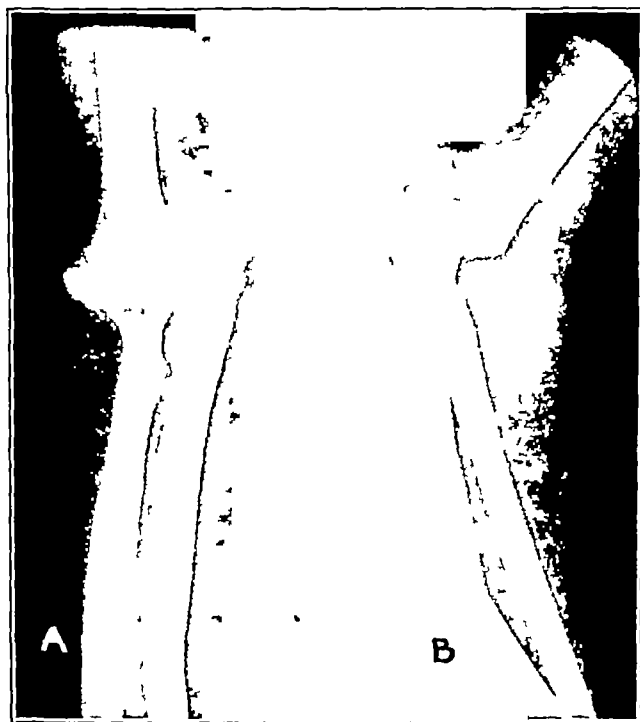


Fig 1 (case 2)—*A*, anteroposterior and, *B*, lateral roentgenograms of left elbow taken two years following sideswipe fracture. There is a complete disorganization of the elbow joint, but the patient has a satisfactory range of painless motion through the pseudarthrosis at the site of the humeral fracture.

angle to 10 degrees inside a right angle. There was pronounced limitation of supination and pronation of the forearm. Performance of his duties was satisfactory, but he was subsequently discharged from the service because of his disability.

CASE 4—On July 13, 1943, a 20 year old Army private was driving, with his left elbow out the driver's window, when his car was sideswiped by a truck traveling in the opposite direction. Two hours later he was admitted to this general hospital in a mild degree of shock, with a gaping wound over the posterior aspect of the left elbow, from which protruded several loose pieces of bone. He

was first treated for shock and then taken to the operating room, where the wound was thoroughly debrided and the loose fragments of bone removed. The ulnar nerve was seen to be exposed but appeared to be intact. The triceps tendon was severed, and no attempt was made to resuture it because of the danger of constricting circulation further in the forearm. At the time of admission it was noted that no radial pulse was palpable and the entire hand was cold and cyanotic. The edges of the laceration were loosely approximated with interrupted black silk sutures and a molded posterior plaster splint applied to the arm with the elbow in complete extension. The following morning a cervical sympathetic block was performed, but there was no noticeable improvement in the circulation to the hand. Subsequently, all the finger tips became gangrenous, and on Aug. 24, 1943, a guillotine amputation was performed through the distal third of the humerus at the site of the fracture. Secondary closure of the skin was done approximately

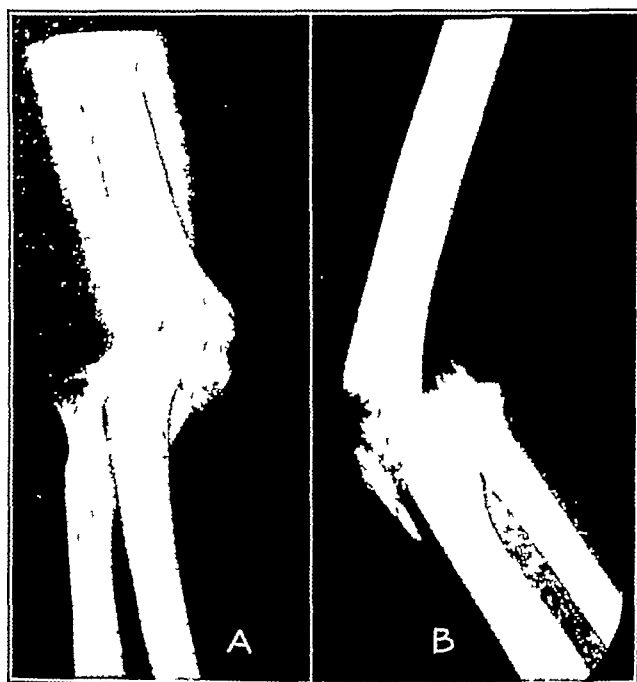


Fig. 2 (case 5) —*A*, anteroposterior and, *B*, lateral roentgenograms of left elbow taken four months following sideswipe fracture. There is a persistent dislocation of the elbow joint, with loss of the major portion of the lateral humeral condyle and a nonunion of the small remaining fragment of the olecranon. Despite the pronounced disorganization of the joint, there is a satisfactory range of painless motion.

five days later, and the postoperative course was entirely uneventful. After healing of the amputation stump, the patient was transferred to an amputation center, where he was fitted with a prosthesis, educated in its use and discharged from the service. At the present time he is working as a clerk for a railroad company, using his prosthesis to fair advantage.

CASE 5—On Oct. 7, 1943, a 22 year old Army private first class was driving his car, with his left arm resting on the frame of the car window, when he was sideswiped by a truck passing in the opposite direction. He was taken immediately to an Army station hospital, where it was found that he had a badly lacerated

arm with a compound fracture of the distal end of the humerus and the olecranon process of the ulna. His wounds were debrided, small pieces of bone were removed, together with the lateral epicondyle of the humerus, and the wound was primarily closed. The fracture was then manipulated and a plaster cast applied, extending from the base of the fingers to the axilla, with the elbow flexed at 90 degrees. The patient was subsequently transferred to this general hospital, where immobilization was continued until Dec 2, 1943, when the plaster cast was removed and active motion of the elbow and forearm begun. After a period of six weeks following removal of immobilization, the patient had a good functional result in spite of a poor anatomic elbow joint as seen on roentgenologic examination (fig 2 *A* and *B*). He had almost complete flexion of the elbow, and extension was limited to 60 degrees outside a right angle. He was discharged to permanent limited service and has continued to do satisfactory service in that capacity.

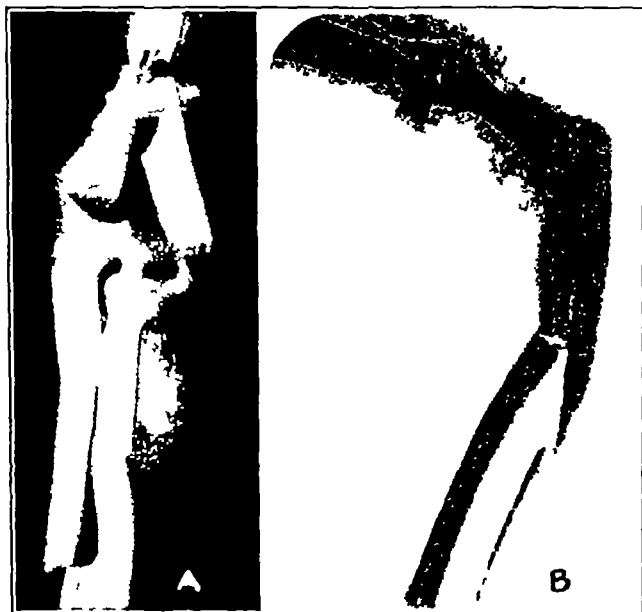


Fig 3 (case 6)—*A*, anteroposterior and, *B*, lateral roentgenograms of left elbow taken nine weeks following sideswipe fracture. There is little evidence of healing in the extensively comminuted humeral fracture.

CASE 6—On May 18, 1944, a 23 year old Army private was driving, with his left elbow out the driver's window, when his car was sideswiped by an oncoming truck. The resulting injury consisted in a badly compounded, comminuted fracture of the distal end of the humerus, compound fractures of both bones of the forearm and a severe avulsive wound over the elbow. He was first seen in an Army station hospital, where he was treated for shock and his wounds were debrided and dressed. Twelve hours later he was transferred to an Army general hospital, where at once his wounds were extensively debrided because of a spreading gas bacillus infection. It was noted at that time that there was a complete severance of the ulnar nerve and an incomplete severance of the median nerve. Amputation of the extremity was considered but not performed. The patient was treated with antigas serum and penicillin parenterally and roentgen ray therapy locally on his arm. He experienced a stormy convalescence and it

was decided that he should be transferred to a plastic-orthopedic-neurosurgical center as soon as his condition permitted. Consequently, on July 18, 1944, he was admitted to this general hospital, with his left arm encased in a long arm cast, which was badly soiled from drainage. Examination following removal of the cast revealed a large granulating wound over the entire posterior aspect of the elbow, measuring approximately 12 inches (30.4 cm) in length and 5 inches (12.7 cm) in breadth. Little evidence of healing of the fractures could be demonstrated clinically or on roentgenologic examination (fig 3*A* and *B*). Numerous sequestrectomies were done at the site of the humeral fracture until there was a cessation of all drainage, by Oct 15, 1944. A full thickness pedicle graft was applied to the elbow, and the patient has recently had a repair of his ulnar nerve. The fractures of the forearm are well healed, but nonunion persists at the site of the fracture of the humerus (fig 4*A* and *B*). On completion of his neurosurgical treatment he will be returned to the orthopedic section for bone graft



Fig 4 (case 6)—*A*, lateral and, *B*, anteroposterior roentgenograms of same elbow as in figure 3, taken one year after injury, showing typical nonunion and pseudarthrosis at the site of fracture in lower third of humerus. There is little motion in this elbow joint.

of the fracture of the humerus. Range of motion at the elbow joint at present is limited to 15 degrees outside a right angle to 15 degrees inside a right angle, including motion at the site of nonunion in the humerus.

CASE 7—On Aug 18, 1944, a 23 year old Army sergeant was driving, with his left elbow out of his car window, when he was sideswiped by a truck going in the opposite direction. He sustained compound fractures of the supracondylar region of the humerus, the olecranon process of the ulna and the proximal and distal third of the radius. He was first given medical treatment in a civilian hospital and then was transferred to an Army station hospital, where, on Aug 20, 1944, thorough debridement and cleansing of the wound were done and the arm

was immobilized in a plaster cast. It was noted at that time that there was loss of the major portion of the distal third of the humerus, with the exception of part of the medial epicondyle, and loss of the olecranon process of the ulna. He

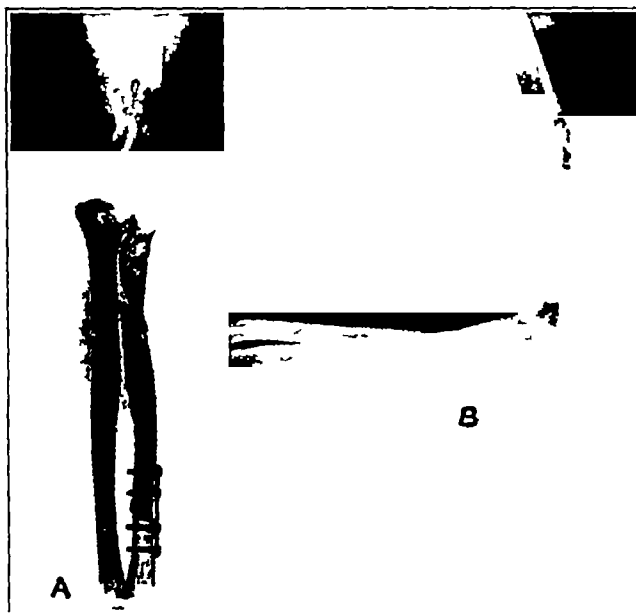


Fig 5 (case 7)—*A*, anteroposterior and, *B*, lateral roentgenograms of left elbow ten months following sideswipe fracture. The entire elbow joint has been removed, including the olecranon and the distal 5 inches (12.7 cm) of the humerus. Most of this bone was removed at time of initial débridement. There is no peripheral nerve injury.

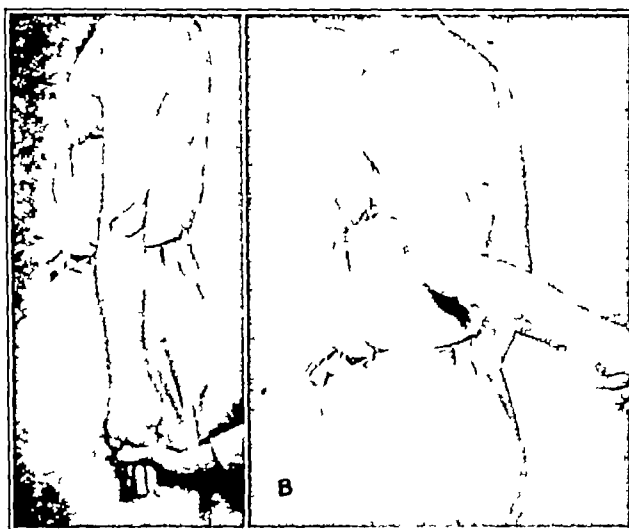


Fig 6 (case 7)—*A*, same patient whose roentgenograms are shown in figure 5. A pedicle graft has been applied to the left elbow. The site of the pedicle flap may be seen on the left wall of the chest. There is pronounced instability of the left elbow.

was transferred to an Army Air Forces regional hospital, where, on August 27, an attempt at secondary closure was made, but, because of soft tissue loss, it could not be done satisfactorily. At that time it was noted that the three major nerves in the region of the elbow as well as the brachial artery were intact. The fracture of the distal end of the radius was plated, and the fracture of the proximal end of the radius was reduced and held with a wire loop. The patient was subsequently transferred to this general hospital on September 26, with a large granulating wound over the posterior aspect of the elbow. On October 12, the loose medial epicondylar fragment was removed in an attempt to clear up the persistent drainage (fig 5 *A* and *B*). The wound soon healed, and, because of the extensive scarring over the posterior aspect of the elbow, a full thickness abdominal pedicle graft was applied on March 2, 1945 (fig 6*A*). At the present time the patient has a flail elbow with pronounced instability and little active motion (fig 6*A*). An acrylic resin implant is to be applied to the end of the humerus to see if a longer fulcrum can be established for better motion of the elbow. If this is not satisfactory, arthrodesis of the elbow will be done.

COMMENT

We feel that this small series of 7 cases presents a fairly typical cross section of the universally poor results obtained in sideswipe fractures. In 2 of the 7 cases reported on amputation through the lower third of the humerus was performed, and in 2 additional cases (cases 6 and 7) amputation might have been performed without criticism. In the 2 latter cases, however, there was never any serious impairment of circulation in the forearm and hand, and the 2 patients will eventually have a much better functional result than could be obtained by amputation.

It is also of interest to note that in 3 of the cases in this series a nonunion of the supracondylar fracture of the humerus developed. In 2 instances, the pseudarthrosis permitted a fairly useful range of painless motion of the elbow. In the third case a bone graft will be necessary to obtain healing in the fracture, and at the same time arthrodesis of the elbow joint may be done.

Because of the many factors involved in this injury, no set routine for treatment can be outlined. Each case necessarily must be individualized. The badly lacerated wounds should be debrided by sterile technic, with removal of foreign material and all isolated, far removed fragments of bone. Nerves should be primarily sutured if there is disruption of their continuity and they are easily visualized. If there is some impairment of circulation, cervical sympathetic blocks may be instituted. Obviously, the chief criterion for amputation through the site of the fracture is severe impairment of the peripheral circulation. If it is necessary to ligate the brachial vessels or if these vessels have been thrombosed by trauma, amputation is usually the procedure of choice. Every effort should be made, however, to salvage a forearm and hand if there is any chance for restoration of function, since even a poorly functioning hand is in most cases much better than a prosthesis. The amputation

is usually at the level of the fracture site in the supracondylar region of the humerus, and primary amputation may be done if there is adequate skin to cover the stump without tension. As much of the upper arm should be salvaged as possible. Although a primary amputation was done in 1 of our cases, it is an established policy in the Army now to perform guillotine amputations in all cases of compound fractures in which amputation is indicated, this is followed by a period of skin traction on the stump and then secondary closure or reamputation at a higher level after all danger of a spreading infection in the extremity has disappeared.

The major fragments of bone should be approximated as best they can be, and external immobilization applied. This immobilization is usually a full arm plaster cast, extending from the axilla to the metacarpophalangeal joints, with the elbow flexed at 90 degrees and the forearm in neutral position of rotation. If the humeral fracture extends much above the supracondylar region, however, a shoulder spica cast may have to be applied. If there is any evidence of vascular embarrassment, the cast should be bivalved and only the posterior shell employed until there is no further chance of vascular impairment.

The use of internal fixation by means of metal plates, screws or wires is not condemned but is seldom found to be feasible in the presence of the extensive comminution of the fragments which is usually encountered. The fractures of the radial and ulnar shafts are more apt to warrant the employment of internal fixation than are the comminuted fractures extending into the elbow joint itself. The use of transfixing wires incorporated in the cast or the use of skeletal traction for reduction of the forearm fractures may be employed.

So far as the fractures immediately about the elbow joint are concerned, adequate immobilization is usually secured by a plaster cast. Since ankylosis of this joint is anticipated, the forearm is usually held at a right angle to the upper arm. If, however, this position produces constriction of the brachial vessels, the forearm may be extended as much as necessary for a few days until the swelling of the arm recedes sufficiently to permit flexion to a right angle.

Immediate resection of the entire elbow joint or at least resection of the comminuted fragments composing the distal end of the humerus has been recommended by some orthopedists as the treatment of choice in this type of injury. This was done in 1 of our cases. We believe that it is better at the time of the initial debridement to remove only the completely detached fragments of bone which are certain to sequestrate and to reserve a complete resection of the joint for a later procedure. In this way there will not be such an extensive removal of bone, and at a later date the surgeon may better choose the exact level of the resection. In some instances, too, an arthroplasty may even

be feasible after the fractures have healed. In any event, a more stable and more useful elbow joint will result if too much bone is not removed. Furthermore, an arthrodesis of the elbow joint may be indicated later, especially if the person is forced to make his livelihood at manual labor. If much bone is removed at the time of the initial debridement, subsequent arthrodesis is made extremely difficult.

Because of the extensive damage to the skin overlying the posterior aspect of the elbow, it is frequently necessary to employ a skin graft to obtain healing of the wound. A split thickness graft may suffice, but if any operative work on the elbow is contemplated a pedicle graft from the abdomen is usually applied (fig 6A).

SUMMARY

1 "Sideswipe fractures" are mutilating fractures of the left elbow sustained when the driver of an automobile has his elbow resting on the window frame at the moment his car is sideswiped by an oncoming vehicle.

2 Because of the usually extensive damage to soft tissue these fractures are difficult to treat and are prone to produce a poor result.

3 Although amputation through the humeral fracture site may be necessary due to pronounced circulatory impairment, every effort should be made to salvage the forearm and hand if there is any chance for restoration of function.

4 The general plan of treatment for fractures of this type has been discussed.

5 The occurrence of this fracture could be largely prevented if the medical profession as well as the general public could be better informed concerning the manner in which the fracture is sustained.

ANAPHYLAXIS-LIKE REACTIONS PRODUCED BY ASCARIS EXTRACTS

I The Changes in the Histamine Content and the Coagulability of the Blood in Guinea Pigs and in Dogs

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IN a preceding paper, we have studied¹ the mechanism of shock produced by hydatid fluid (*Taenia echinococcus*) when injected into dogs. We have reached the conclusion that the material responsible for the shock is not precipitated by 5 per cent trichloroacetic acid, does not dialyze through cellophane paper and resists boiling temperature for a long time. From those preliminary studies we have been able to obtain a fairly purified material which produces profound shock in dogs. This shock is of the indirect type, since a second injection of the same material does not produce any appreciable effect (desensitization). Furthermore, in certain cases there occurred an evanescent incoagulability of the blood and in a few animals complete incoagulability was observed, suggesting a liberation of heparin from tissues into the blood stream. Histamine was found to be increased in the circulating blood in a few animals but in most of the cases there was rather a drop in the blood histamine in dogs into which hydatid fluid had been injected. This observation was somewhat contradictory to that made by Graña, Recarte and Balea² in Montevideo, since a definite increase in blood histamine was found by these authors in every dog into which hydatid fluid had been injected. This point was not understood at the time we had written the mentioned reports but by now we are inclined to assume that differences in the degree of sensitization to the substances of *T. echinococcus*, very common in Uruguay and very rare in Brazil, might explain the discrepancy cited.

While we were concluding the experiments on hydatid fluid, it occurred to us that other nematodes might contain similar toxic substances, a fact which would contribute to a better understanding of the shock produced in the dog by hydatid fluid. Fortunately, as

From the Department of Biochemistry and Pharmacodynamics, Instituto Biológico

1 Rocha e Silva, M., and Graña A. *Am J Physiol*, to be published.

2 Graña, A., Recarte P., and Balea, E. *Rev Soc argent de biol* **19** 444, 1943

concerns the *Ascaris* group, the way was opened by previous studies³ showing that extracts prepared from ascaris produce hypotension in dogs. From *Ascaris lumbricoides*, Shinamura and Fuji⁴ were able to isolate an "albumose-peptone" which they designated as "askaron," a very toxic substance for dogs. More recently, Machebouef and Mandoul⁵ were able to prepare extracts from *Ascaris megaloccephala* which produced in the guinea pig lung an emphysema which is indistinguishable from that produced by anaphylactic shock. The active material obtained from ascaris by Machebouef and Mandoul was soluble in 4 per cent trichloroacetic acid and in 50 per cent ethyl alcohol. Prolonged dialysis did not remove the active substance. In 1939, O. Bier⁶ was able to show that *A. lumbricoides* contains a substance very active in producing an anaphylactic-like shock in guinea pigs. These previous observations appeared to justify the belief that *A. lumbricoides* might provide a suitable source for obtaining a material producing a shock of the anaphylactic type in dogs. Our hopes were largely confirmed by the observation that extracts from *A. lumbricoides* are extremely powerful in producing severe to fatal shock in dogs, showing all the characteristics of anaphylactic shock, namely, liver congestion, incoagulability of the blood, desensitization after recovery and appearance of histamine in the blood. The shock, however, is extremely severe, and almost all animals react violently to an injection of a few cubic centimeters of the ascaris extract.

MATERIALS AND METHODS

Fractionation of the Ascaris Extracts—The *A. lumbricoides*, collected from hogs in large quantity at the slaughter house, were divided in a meat chopper and thoroughly ground in a colloid mill apparatus. The homogenous pulp obtained was treated with an equal volume of a 10 per cent solution of trichloroacetic acid, and the mixture was mechanically stirred for two hours at room temperature and left overnight in the icebox. The next day the material was centrifuged and the opalescent solution submitted to prolonged dialysis through cellophane paper, for at least forty-eight hours, until freed of trichloroacetic acid. The final p_H was usually around 5.8 to 6. The material was neutralized with sodium carbonate, and the solution used in many experiments is designated as fractions E_0 , EE_0 , and EEE_0 , etc.

The material was further purified by submitting it to the following procedure. About 100 cc. of E_0 solution was added with stirring to 100 cc. of absolute alcohol. A heavy flocculent precipitate was obtained, consisting mostly of glycogen (strong iodine reaction). The material was centrifuged off and the supernatant concentrated to syrup in vacuo at 80 F. The addition of acetone precipitated a material which was further dried by successive additions of acetone. The buffy powder obtained

3 Leroy, A. Arch. internat. de physiol. **9** 276, 1910. Emery, F. E., and Herrick, C. A. Am. J. Physiol. **91** 143, 1929.

4 Shinamura, T., and Fuji, N. J. Coll. Agric. **4** 189, 1917, cited by Essex, Markowitz and Mann.²⁰

5 Machebouef, M., and Mandoul, R. Compt. rend. Soc. de biol. **130** 1032, 1939.

6 Bier, O. Personal communication to the author.

is designated as E₁, EE₁ and so on. This powder was dissolved in water, filtered and submitted to further dialysis against distilled water for forty-eight to seventy-two hours. The solution was then concentrated in vacuo and dried with acetone. Estimations of nitrogen in this material (E₁₁) gave 12 to 15 per cent of total nitrogen. It gave a strong biuret reaction (4 plus), a positive Sakaguchi reaction (3 plus), an undecided Molisch reaction (plus-minus), a negative Hopkins-Cole reaction (minus) and a negative Knoop reaction (minus) after prolonged dialysis with concentrated hydrochloric acid. The material E₁₁ did not precipitate with a 5 per cent solution of trichloroacetic acid but gave a precipitate with a sulfuric solution of phosphotungstic acid. From those data one might conclude that the substance which produces shock in dogs is not a protein but can be included in the group of the proteoses of large molecular weight. The questionable Molisch reaction might be due to traces of the polysaccharide (glycogen) present in the crude extracts.

The glycogen fraction (G₁) which is precipitated from E₀ with an equal volume of absolute alcohol was easily purified by successive redissolutions in isotonic solution of sodium chloride and reprecipitations with an equal volume of absolute alcohol. The final material gave a strong iodine reaction for glycogen and a strong Molisch reaction (4 plus). This material is responsible for the opalescence of the ascaris extracts. Apparently related to this fraction is the polysaccharide prepared from *A. lumbricoides* by Campbell.⁷

Antithrombin Assay—A solution of human thrombin was prepared according to the indications of Quick.⁸ The addition of 0.1 cc. of the full strength (1/1) thrombin solution to 0.2 cc. of normal oxalated dog plasma produced a firm clot in about six to seven seconds at room temperature. A series of dilutions of human thrombin solution was made and 0.1 cc. of each pipetted into small test tubes containing 0.2 cc. of the plasmas to be tested. The clotting times in seconds were plotted in curves against the thrombin dilutions. In the case of dog 17, we have calculated the approximate antithrombin content (heparin) by applying the formula $ct = a + k/c$ (where ct = clotting time and c = concentration of thrombin). The antithrombin values indicated in figure 4 were calculated by subtracting from 100 each value for the thrombin concentration ($100 - c$).

RESULTS

Characteristics of the Shock Produced in Dogs by Ascaris Extracts—Injected intravenously in dogs, the deproteinized and dialyzed E₀ extract from *A. lumbricoides* produced severe shock with great enlargement of the liver, stasis in the abdomen, enormously increased pressure in the trunk of the portal vein and incoagulability of the blood. After the administration of the extracts and after a latent period of one and one-half to two minutes, blood pressure in the carotid artery begins to fall sharply, the animal shows profound restlessness even under deep anesthesia. After a few minutes, the liver shows the characteristics of an enormous stasis, its borders lose their sharpness and its volume almost doubles. The color of the organ rapidly changes into a dark brown or black. Only 1 dog in 19 did not show this extremely serious

7 Campbell, D. H. J. Infect. Dis. **59** 266, 1936.

8 Quick, A. Am. J. Physiol. **116** 535, 1936.

picture of shock During recovery, before acquiring its peculiar reddish taint, the liver presents a somewhat reticulate picture in which regions in light brown alternate with areas of dark or blackish brown taint If, in the case of recovery, the same amount of ascaris extract is injected again, the animal does not react (chart 1) This is an evidence that the shock is indirect and not dependent on a primary toxicity of the extract In most cases, after an incomplete recovery, the animal goes very rapidly into secondary shock and dies after two to three hours The blood collected immediately after the injection of the extracts sometimes showed increased tendency to clot (in one minute), but the blood collected three to four minutes after the onset of the shock shows definite increased clotting times or complete incoagulability (no clot after twenty-four hours' standing at room temperature) This incoagulability was so common and constant that it usually gave a rough picture of the

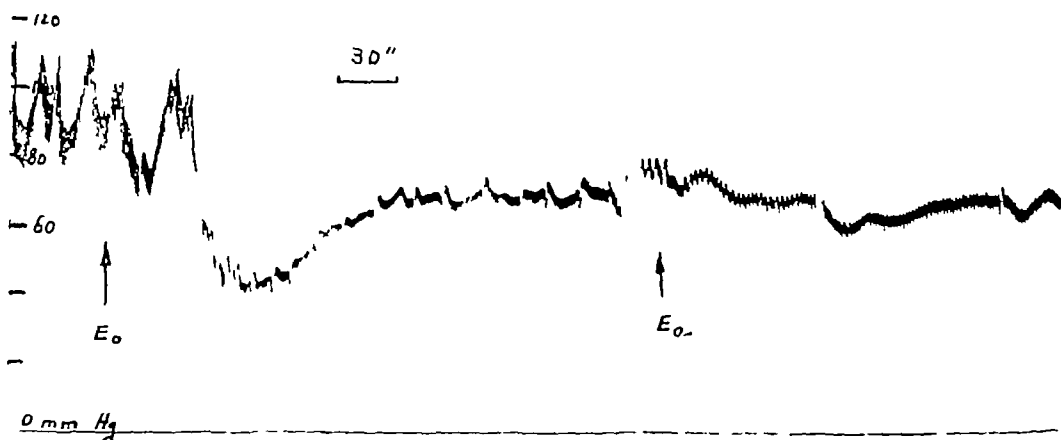


Chart 1 (dog 43) —At the arrows, 15 cc of an aged ascaris extract was injected The reaction was exceptionally mild After recovery, the animal did not react with the same dose of the extract (desensitization)

severity of the shock In cases of the severest shock the incoagulability of the blood was infinite (∞), even in samples collected two or three hours after the onset of the shock, just before death A striking and constant observation was the disappearance of the buffy coat and of the platelets in the blood collected after the injection of the extracts This was apparent after a slow centrifugation (1,200 revolutions per minute) for five minutes, while the oxalated blood collected before the injection of the material usually showed an incomplete sedimentation with a very turbid plasma, the samples collected in identical circumstances after the injection of the ascaris extracts or after the onset of the shock showed an extremely rapid sedimentation of the erythrocytes, almost complete disappearance of the white cell layer (buffy coat) and a perfectly clear supernatant plasma Direct leukocyte and platelet counts

confirmed this preliminary observation, showing in many cases an almost complete disappearance of the white blood cells and platelets after the injection of 5 to 10 cc of the E_0 extracts

Through this brief discussion of the most important characteristics of the shock produced in dogs by the injection of a deproteinized and dialyzed ascaris extract, it is apparent that this shock is extremely similar to anaphylactic shock in dogs. Every symptom which one is accustomed to observe to be severe in a certain number of dogs sensitized to horse serum appears regularly after the injection of ascaris extracts. This would induce one to consider the shock produced by ascaris extracts as a "markedly severe anaphylactic shock" and to study its mechanism of production in an attempt to clarify the mechanism of anaphylactic shock in the dog. This was the main purpose of the present papers.

Blood Histamine During the Shock Produced by Ascaris Extracts—The dogs were anesthetized with morphine sulfate and dial, the blood pressure of the carotid artery recorded and the femoral veins exposed for collecting samples of blood and injecting the extracts. The samples of blood (5 to 10 cc) were collected in syringes coated with petrolatum without anticoagulant, and 4 cc from each sample was pipetted into a test tube containing 5 cc of 10 per cent solution of trichloroacetic acid for extraction of histamine by Code's method⁹ and estimation of its effect on guinea pig ileum. The figures for normal blood histamine in the dogs submitted to morphine-dial anesthesia were definitely lower than those reported in a previous paper¹ to have been observed in dogs submitted to chloralose anesthesia. The figures for the histamine content in 1 cc of blood oscillated from 0 to a maximum of 0.10 microgram, with an average value of 0.04 microgram per hundred cubic centimeters, in 17 different animals. Samples were collected (*a*) before the injection, (*b*) during the fall of the blood pressure in the carotid artery, (*c*) when the pressure was stabilized at a minimum, (*d*) after ten to fifteen minutes of the fall, (*e*) during recovery and (*f*) just before death. Those estimations permitted the tracing of curves in which the blood histamine is correlated to the blood pressure values. Chart 2 shows the curves obtained in 4 dogs submitted to the shock produced by ascaris extracts. It is apparent that the increase in blood histamine is concomitant with the steep fall of the blood pressure in the carotid artery, but the maximal values for histamine in the blood are usually attained several minutes after the onset of the shock. In many cases this increased histamine content in the femoral blood persisted until death, but usually the drop started somewhat earlier and the normal level was quickly attained.

⁹ Code, C. F. J. Physiol. 89: 257, 1937.

TABLE 1—Changes in Histamine of Blood and Liver and in the Coagulability of the Blood in Dogs Submitted to Shock by *Ascaris* Extract

TABLE 1—Changes in Histamine of Blood and Liver and in the Coagulability of the Blood in Dogs											
Dog	Weight, kg	Material Injected	Intensity of Shock*	Blood Histamine, Megm/Cc					Liver Histamine, Megm/Cc		Incoagulability of Blood †
				Before Injection	After Injection				Before Injection	After Injection	
					2 Min	3 to 4 Min	10 Min	Later			
3	9.3	E ₀	++++	0.03	0.43	0.27	0.05		25.1	8.0	0, +, +, +
4	7.3	E ₀	+++	0.04	0.05				19.1	4.3	0, +, +, +, +
5	9.0	G ₁	++++	0.04	0.20	0.50	0.11		12.0	15.0	0, +, +, +, +
6	7.0	E ₁ (40 mg)	++++	0.01	0.22	0.12			30.0	6.0	0, +, +, 0
7	10.0	E ₁ (100 mg)	++++	0.04	0.09	0.60	0.00		12.0	10.0	0, +, +, +, +
8	10.0	E ₁ (100 mg)	++++	0.09	0.15	0.80	0.07		24.0	8.9	0, +, +, +, +
9	12.5	E ₀	+++	0.00	0.03	0.11	0.00		19.7	8.4	0, +, +, +, +
10	12.0	E ₀	++++	0.00	0.16	0.16	0.62		18.5	22.3	0, +, +, +, +
11	9.5	E ₁₁ (50 mg)	++++	0.07	0.10	0.20	0.26		23.8	8.1	0, +, +, +, +
12	8.5	EE ₀	+++	0.00	0.37	0.23	0.00		10.2		0, +, +, +, +
13	8.5	EE ₁ (100 mg)	++++	0.14	0.10	0.18	0.02				0, -, +, +, +
14	8.5	EE ₀ (15 cc)	++++	0.07	0.10	0.05	0.01		0.20		0, 0, +, +
15	8.5	EE ₀ (10 cc)	++++	0.07	0.00	0.04	0.21		0.08		0, 0, 0, +
16	8.5	EE ₀ (15 cc)	++++	0.04	0.08	0.12	0.31		0.18		0, +, +, +, +
17	10.5	EE ₀ (3 cc)	+++	0.04	0.15	0.24			0.11		0, +, +, +, +
18	5.5	EE ₀ (15 cc)	+	0.00	0.10				20.2	11.1	0, +, +, +, +
19	5.5	EE ₀ (10 cc)	+++	0.04							0, +, +, +, +
Averages											
* As indicated in the table mean +, +, +, death in fifteen to twenty minutes, no recovery observed +, +, +, death in one hour, with a partial recovery blood indicate -, incoagulability (∞) for more than twenty four hours											

* The grades of shock as indicated in the table mean +, ++, +, death in fifteen to twenty minutes, no recovery observed; ++, death in one hour, with a slight tentative recovery, +, partial recovery and death from secondary shock in two to three hours, +, very slight shock and prompt recovery, 0, no shock † The grades or more but no incoagulability ++, complete incoagulability (∞) for more than twenty four hours in ten minutes or more

That this histamine which appears in large amounts in the circulating blood comes from the liver is clearly shown by the decrease in the total histamine extractable from pieces of liver after shock. Fragments of the liver of 10 dogs were taken before and after the injection of the ascaris extracts, and in almost all cases in which the shock has been severe there has been considerable reduction in the histamine content in 1 Gm of liver

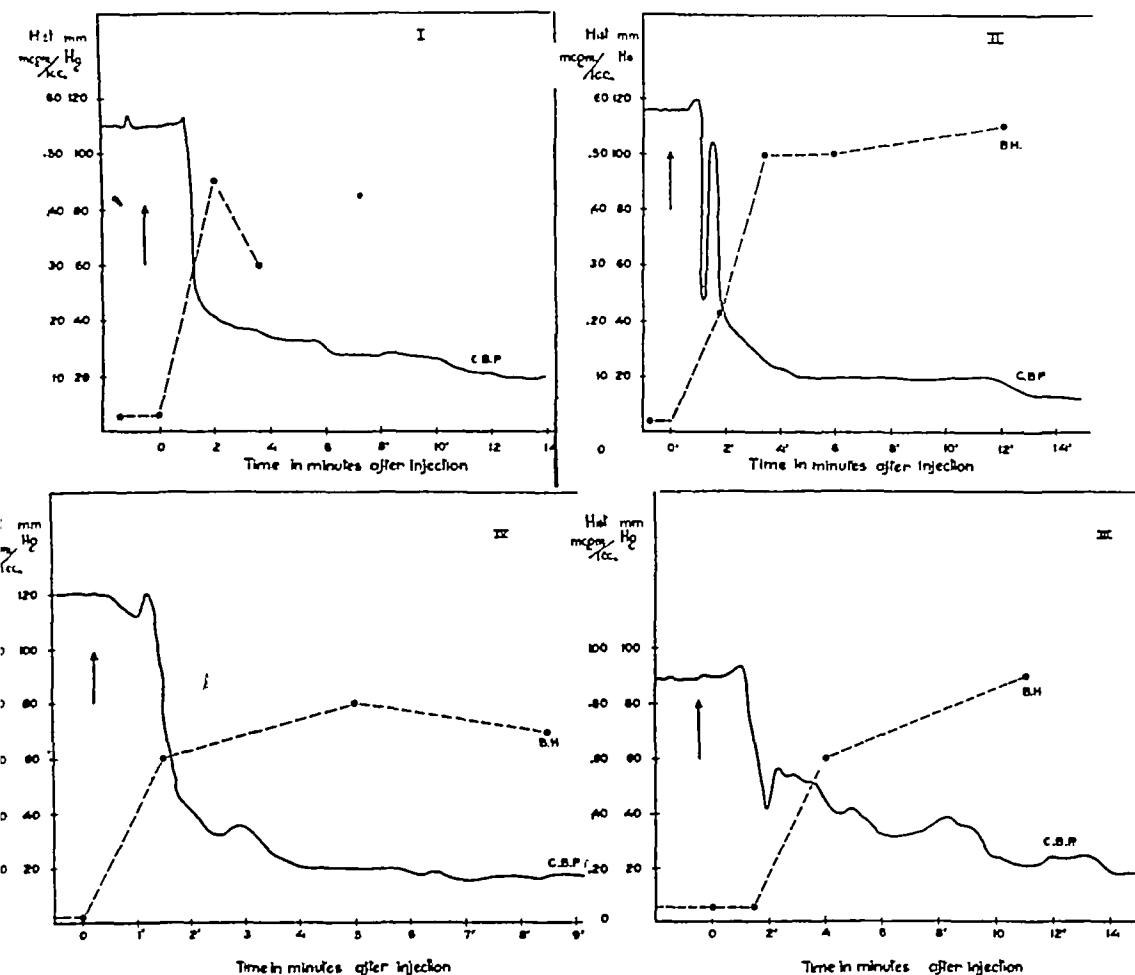


Chart 2—Variations in blood histamine and the blood pressure of the carotid artery after the injection of materials extracted from ascaris (at the arrows), I, dog 3, II, dog 6, III, dog 8, IV, dog 10. For details, see table 1

Impressive were the increases in blood histamine in samples taken from the portal vein. The blood was collected after quick exposure of the trunk of the portal vein. Usually, the hemorrhage through the hole pierced by the needle was very severe or uncontrollable, owing to the increased pressure in the portal circulation combined with the incoagulability of the blood. This bleeding relieved somewhat the abdominal

condition and improved the appearance of the liver. As shown in table 2, the histamine contents in the samples of blood taken from the portal vein were usually greater than those estimated in a sample collected almost simultaneously in the femoral vein. As shown in the experiments made with dogs 6, 13, 14 and 17, this differential in the histamine contents in the femoral and the portal veins attains a considerable value, since in those dogs the amount of histamine in the portal blood was in 3 cases twice as large as, and in 1 case four times larger than, that estimated in the blood in the femoral vein. In the case of dog 17 (chart 4) several samples of blood were simultaneously collected in the femoral vein and in the portal vein. Contrasted with the low peak of histamine content in the femoral vein, there was a high peak of histamine in the portal vein. If one considers the enormous diffusibility of the histamine through the whole circulatory apparatus, this

TABLE 2—*Comparative Estimations of Histamine in Blood Samples Collected in the Portal and Femoral Veins*

Dog	Time After Injection, Min	Histamine Content, Mcgm /Cc	
		Femoral Vein	Portal Vein
6	6	0.56	1.10
8	12	0.90	1.05
10	9	0.70	0.85
11	7	0.07	0.07
13	15	0.62	1.25
14	10	0.26	0.44
17	3	0.06	0.25

histamine stagnation in the portal system is suggestive of a tremendous obstruction in the capillaries and the small vessels of the liver, almost stopping the circulation in the suprahepatic veins. This is consistent with the macroscopic appearance of the enormous stasis in the liver, as described before.

The Incoagulability of the Blood—As indicated in table 1, the samples of blood taken after the injection of ascaris extracts almost always remain unclotted for twenty-four hours (++) Usually, the first sample taken two to three minutes after the injection, during the fall of the blood pressure of the carotid artery, clotted in ten to twenty minutes (+), the third sample, however, was usually incoagulable when shock was severe. In a few animals, samples were taken and ovalated for a rough estimation of the antithrombin potency, employing human thrombin as reagent, according to the method described by Quick.⁸ In most cases in which the blood remained incoagulable, even the addition of the full strength thrombin solution (1/1) was unable to induce coagulation after a reasonable period of time. That this incoagulability was due to the appearance of an antithrombin factor (heparin) in the circulating blood

was shown by mixing a proper amount of it with normal oxalated plasma. This mixture did not clot when treated with the thrombin solution. Chart 3 shows the antithrombin curves of dogs 16, 17 and 18. From the values of the clotting times of the plasmas of dog 17, in contact with the full strength thrombin solution, a curve was drawn indicating the increase in antithrombin activity (heparin) in correlation with the increases in the histamine content in femoral and portal blood, as well as with the variations of the blood pressure in the carotid artery (shock). As shown in chart 4, the peak of heparin is attained a little later than the peak of histamine and the fall in blood pressure of the carotid artery.

In dogs 15 and 19, all samples taken two minutes after the injection of the ascaris extract did not clot, even after addition of the full strength thrombin solution. It has been somewhat difficult to graduate the amount of extract which was injected in order to have a moderately increased clotting time. The incoagulability of the blood was extreme in most cases, the blood remaining incoagulable for twenty-four hours. Even when death occurred after two to three hours, in most cases the clotting times remained high or infinite until death. Usually the blood taken from the portal vein remained unclotted, even in those cases in which the peripheral blood clotted after a reasonable length of time.

Although a strict parallelism between the severity of the shock and the degree of incoagulability of the blood cannot be drawn, there was, however, a rough parallelism, and we have been able to observe that when recovery did occur the incoagulability of the blood was not so extreme. In the cases of dogs 9 and 18, shock was mild or absent, and at the same time the blood did not remain fluid for a long time. We shall show in a future paper that glycogen when given in large doses partially desensitizes the animal to a further injection of ascaris extracts. In a few cases, the animal reacted only slightly to the ascaris extract. In all cases in which shock was mild or absent the incoagulability of the blood was not much changed. If it is true that mild shock did not change appreciably the coagulability of the blood, we cannot affirm, however, that very great shock is always followed by an extreme incoagulability of the blood. In a few cases of fatal shock, the coagulability of the blood was not greatly changed, as will be shown in this paper. It is also difficult to decide whether there is a perfect parallelism between the increases in the blood histamine values and the incoagulability of the blood. Although both phenomena seem to follow the same trend, we think that we are dealing with two substances of very different diffusibilities. Histamine disappeared very quickly from blood, although the antithrombin factor (heparin) frequently remained in the circulation until death. Moreover, histamine can be accurately estimated, while Quick's method of estimating the antithrombin factor is a very rough

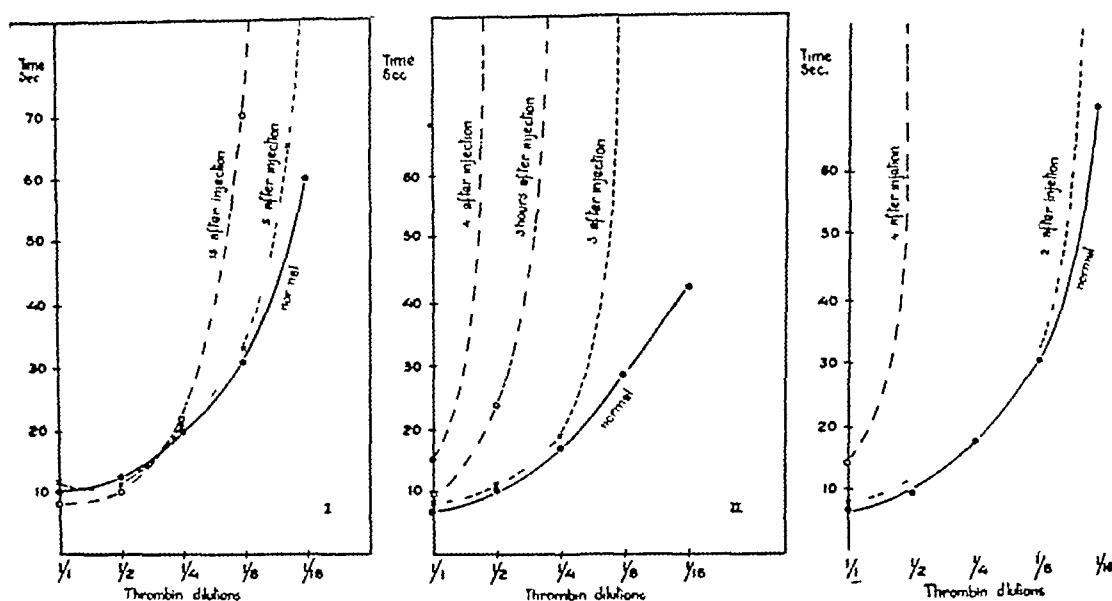


Chart 3—Estimations of the antithrombin factor (heparin) appearing in the blood of animals given ascaris extracts I, dog 18, very weak shock, the changes in blood coagulability were feeble II, dog 17, severe shock, the samples taken between four minutes and two hours after the injection did not clot, even by addition of the full strength thrombin solution III, dog 16, severe shock, all samples taken after four minutes did not clot by addition of 1/1 thrombin solution, and the blood remained in this condition until death z

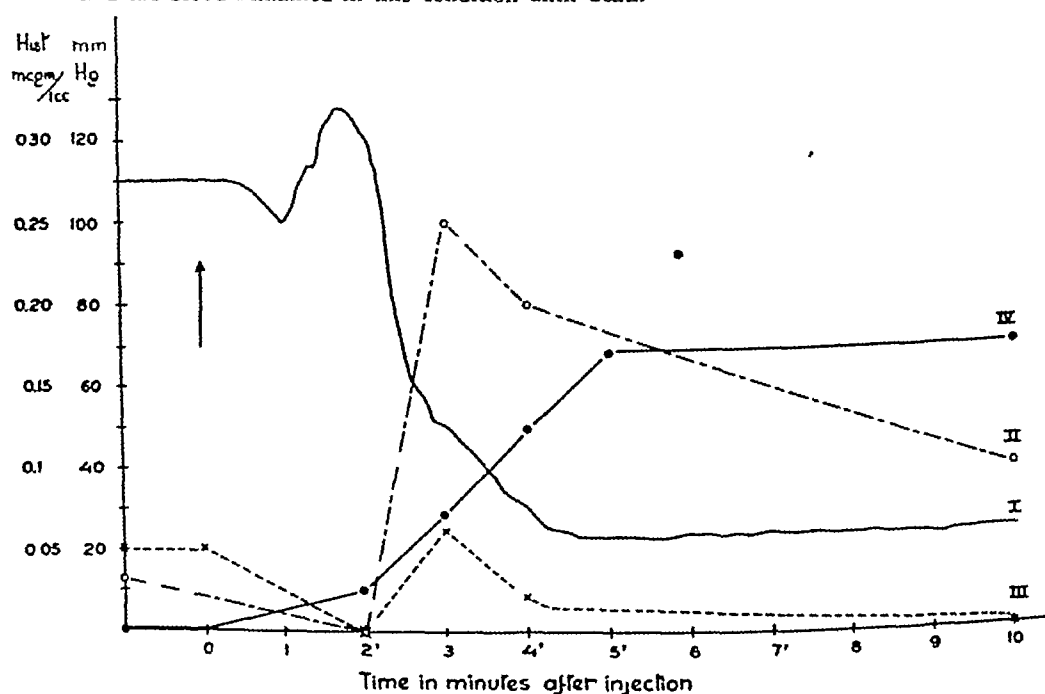


Chart 4 (dog 17) —Correlation between the blood pressure of the carotid artery (I), the histamine content in the portal vein (II), in the femoral vein (III) and the antithrombin potency (IV) The latter was arbitrarily calculated by making complete incoagulability (∞) equal to 100

one and does not give the actual values of the appearing antithrombin potency when the latter attains a value exceeding the potency of the full strength thrombin solution. The protamine test as devised by Jaques and Waters¹⁰ would give more reliable data, but we had no opportunity to apply it.

The Latent Period—Like true anaphylaxis, the shock produced by ascaris extracts starts one and one-half to two minutes after the intravenous injection of the material. An accurate study of the changes in the circulating blood during this latent period is most desirable, since it is during this time that the anaphylactic "explosion" takes place. We have followed in a few cases the changes of the histamine content in the blood of the portal and femoral veins, as well as estimated the approximate amount of the antithrombin factor (heparin) before and during the latent period and after the onset of the shock in dog 17. It is apparent from data shown in chart 4 that the histamine peaks attain values much higher in the portal vein than in the femoral vein and that in both they precede the heparin peak. It became clear that the peak of histamine is preceded by a definite decrease in blood histamine just at the end of the latent period. This disappearance of histamine from the circulating blood coincided with the disappearance of the buffy coat (leukocytes) and platelets from the circulating blood. It is therefore very probable that the increases in the blood histamine as indicated in table 2 do not show in most cases the exact picture of the phenomenon, since between the first sample, taken before the injection, and the samples taken during the fall of blood pressure of the carotid artery there must have been a sharp fall of the histamine values to zero.

Experiments in Guinea Pigs—Machebouef and Mandoul⁵ have described the shock produced by a deproteinized and dialyzed extract from ascaris megaloccephala, when injected intravenously into guinea pigs. Bier⁶ has studied further the question, with extracts made from *A. lumbricoides*. In a few experiments on lung perfusion, Bier has shown that liberation of histamine takes place, that has been confirmed in this laboratory. From those observations it became very clear that the pulmonary emphysema is produced by a local discharge of histamine acting directly on the smooth musculature of the small bronchi. We have performed many experiments to show the *in vivo* liberation of histamine, by estimating the blood histamine before and after the injection of ascaris extracts. Table 3 shows the results obtained in 9 guinea pigs of 350 to 500 Gm of body weight. The first blood sample for histamine estimation was collected by puncture of the heart, injection of ascaris extract through the jugular vein and collection of the last samples from

10 Jaques, L. B., and Waters, E. T. J. Physiol. **99** 454, 1941

the jugular vein or the exposed heart after shock. As shown in table 3, there was in many cases a drop in the histamine content of the blood immediately after the shock, but after four minutes of the injection a rise took place. This rise was very pronounced in a few animals, attaining 1.5 to 2.2 micrograms per cubic centimeter of blood.

TABLE 3—Changes in Blood Histamine in Guinea Pigs into Which *Ascaris* Extracts Were Injected

Guinea Pig	Material Injected *	Blood Histamine, Mcgm /Cc			Degree of Emphysema
		Before Injection	After Injection		
			1 to 2 Min	4 Min.	
1	EEE ₀	0.35	0.25		+++
2	EEE ₀	0.25	0.17		+++
3	EEE ₀	0.30	0.11	0.84	++
4	EEI ₀	0.34	0.37	0.45	+++++
5	EEE ₀	0.44		1.50	+++++
6	EE ₁ (100 mg)	0.41	0.28	0.31	++
7	EEE ₀	0.37	0.27	0.30	+++++
8	EEE ₀	0.33	2.12	2.21	+++++
9	EEE ₀	0.30	0.50	0.72	+++++

* The crude EEE₀ extract was usually injected in the dose of 5 cc intravenously.

COMMENT

The participation of the liver in the production of the anaphylactic shock in the dog has been suspected since early times. Manwaring¹¹ was unable to elicit anaphylactic shock after ligation of the aorta and the vena cava above the diaphragm. Also the injection of the antigen in a sensitized dog with an Eck fistula does not produce shock, as shown by Voegtlin and Bernheim¹² and Denecke¹³. Moreover, the extreme stagnation of the blood in the liver of dogs submitted to anaphylaxis was described by Weil¹⁴. Furthermore, it is a generally accepted theory that the mechanism for this stagnation of blood in the liver can be accounted for by the liberation of histamine from tissues to plasma in which it appears in large amounts, as shown by Dragstedt and Gebauer-Fuelnegg,¹⁵ Dragstedt and Mead¹⁶ and more recently by Code,¹⁷ who has applied careful methods of estimation of histamine to correlate the increases in blood histamine with the drop of the blood pressure in the

11 Manwaring, W. H. *Ztschr f Immunitätsforsch u exper Therap* 8 1, 1910.

12 Voegtlin, C., and Bernheim, B. M. *J Pharmacol & Exper Therap* 2 507, 1911.

13 Denecke, G. *Ztschr f Immunitätsforsch u exper Therap* 20 501, 1914.

14 Weil, R. *J Immunol* 2 525, 1917.

15 Dragstedt, C. A., and Gebauer-Fuelnegg, E. *Am J Physiol* 102 512, 1932.

16 Dragstedt, C. A., and Mead, F. B. *J Pharmacol & Exper Therap* 57 419, 1936.

17 Code, C. F. *Am J Physiol* 127 78, 1939.

carotid artery. Finally, in 1941, Ojers, Holmes and Dragstedt¹⁸ showed that the liver histamine is sharply reduced in severe anaphylaxis in the dog. In the guinea pig an increase in blood histamine was shown by Code¹⁷ to occur immediately after the onset of anaphylactic shock, thus accounting for the emphysema which is the main symptom of the shock in this species of animal.

The shock produced in dogs and guinea pigs by ascaris extracts differs from true anaphylaxis only in one point, namely, that the animals have not been prepared by previous injections of the extract. All characteristics of the anaphylactic shock are present: extreme congestion of the liver and increased pressure in the portal vein, decrease in the liver histamine in dogs, increase in blood histamine in guinea pigs and dogs, incoagulability of the blood due to discharge of an antithrombin (heparin) factor, and desensitization to further injections of the same material after recovery. To reconcile the view of an absence of a previous sensitization of the animal with the anaphylactic nature of the shock, one might invoke the possibility that the animals have been prepared by a sort of endogenous sensitization produced by the presence of parasites in the intestinal tract. This view is not a new one since Van Es and Schalk¹⁹ found that in horses, which frequently are infested with larvae of *Gastrophilus intestinalis*, severe anaphylactic shock developed when extracts of the larvae were given intravenously while the injection of the same material into another species of animal was entirely harmless. In 1931, Essex, Markowitz and Mann²⁰ studied the toxic effects of extracts of two helminths (*Taenia pisiformis* and *Cysticercus pisiformis*) frequently found in the intestinal tract of dogs and concluded that the parasites had a substance which acted primarily as a toxin, since a profound shock developed even in the animals that had never been infested with such parasites, while animals heavily infested sometimes did not react to the extracts. This interpretation, however, cannot be entirely accepted today, since Brunner, Altman and Bowman²¹ have shown the occurrence of cross cutaneous reactions between extracts of different species of nematodes. Extracts of *A. lumbricoides* produced positive cutaneous reactions in a number of animals infected with either *Ascaris canis* or hookworms or whipworms. In the dogs submitted to the experiments described in the present paper, there have been almost always a heavy infection of helminths (more frequently hookworms). We have also verified that after the intracutaneous injection of the ascaris extracts, a definite

18 Ojers, G., Holmes, C. A., and Dragstedt, C. A. *J. Pharmacol. & Exper. Therap.* **73** 33, 1941.

19 Van Es, L., and Schalk, A. F. *Ann. Inst. Pasteur* **32** 310, 1918.

20 Essex, H. E., Markowitz, J., and Mann, F. C. *Am. J. Physiol.* **98** 18, 1931.

21 Brunner, M., Altman, J., and Bowman, K. *J. Allergy* **15** 2, 1944.

cutaneous reaction, with erythema and whealing, very similar to those described by Brunner and associates,²¹ developed in a high percentage of the animals used in our experiments. Thus, one might be induced to assume that dogs in Brazil are almost universally sensitized to ascaris extracts. This is an important point to be settled, since the type of endogenous sensitization induced by intestinal parasites is rather of the allergic and not of the anaphylactic type. We cannot escape concluding that we are here in the limiting boundaries of allergy and anaphylaxis, and the profound analogy between anaphylactic shock and the allergic reaction produced by ascaris extracts shows how fallacious is the distinction that others tried to establish between experimental anaphylaxis and allergy. It is also very remarkable that the purified active substance (E_{11}) extracted from ascaris has no property of a true protein, since it is not precipitated by 5 per cent trichloroacetic acid and yet it does not dialyze and gives a positive reaction to the biuret and the Sakaguchi test and a negative reaction to the Molisch test. The analogy of this kind of antigen (or allergen) with those described by others²² in pollen extracts is manifest. In another circumstance, the classification of this substance as an "Ascaris allergen" inducing true allergic reactions proved to be very sound. In a few experiments on human subjects we have verified that a solution (corresponding to 100 micrograms of nitrogen per cubic centimeter) of the purified ascaris substance (E_{11}) induced cutaneous reactions (whealing), and in 1 case such severe general reactions (headache, edema and constriction of the throat) developed that the patient had to be relieved by an injection of epinephrine hydrochloride.

The extreme severity of the shocks induced in dogs by the injection of the deproteinized and dialyzed extracts from *A. lumbricoides* contrasts with the moderate reactions obtained in a high percentage of animals (30 per cent) sensitized to horse serum or egg albumin. We have now many reasons to believe that the presence of glycogen (or a polysaccharide giving the iodine reaction) or any other macromolecular substance is the factor which aggravates the shock.

Although the increases in blood histamine and the incoagulability of the blood are conspicuous in most animals, we shall show in the next paper that in a few animals after the injection of ascaris extracts there develops a condition without much release of active substances and yet the animal rapidly goes into shock and dies in half an hour. This kind of shock has been tentatively named "mechanical shock" and appears to depend on a mechanical obstruction of the circulation in the hepatic vein by agglutinated hematologic elements. Consequently, one is bound to assume that the shock pro-

22 Rockwell, G. E. *J. Immunol.* **43** 259, 1942.

duced in dogs by ascaris extracts derives from a dual mechanism (a) a clumping of leukocytes and platelets in the capillaries of the liver and (b) an explosive liberation of active substances, like histamine and heparin

SUMMARY

Deproteinized and dialyzed extracts from *A. lumbricoides* produce severe to fatal shock in dogs. Further purification of this material furnished a nitrogenous substance which does not dialyze and yet gives a strong biuret reaction, a positive Sakaguchi reaction and negative Molisch, Knoop and Hopkins-Cole reactions. This substance, which is very active in producing shock in dogs, has been tentatively classified as a proteose of high molecular weight.

The shock produced in dogs by ascaris extracts is indistinguishable from anaphylactic shock, since it is accompanied with enormous engorgement of the liver, drastic reductions in liver histamine, increase in blood histamine and appearance of an antithrombin (heparin) factor in circulating blood and desensitization.

The main increases in blood histamine were found to occur in the portal vein. In many cases, the histamine content in the portal vein was two to six times higher than that found in the femoral vein. This suggests an almost complete stoppage of the circulation in the hepatic veins.

Crude ascaris extracts produce massive emphysema in guinea pigs and death in a few minutes. In a few cases it has been possible to show an increase in blood histamine in this species of animal.

The allergic nature of this anaphylaxis-like reaction produced by ascaris extracts is discussed, and the fallacy of establishing a separation between allergy and experimental anaphylaxis is emphasized.

ACUTE GASTRODUODENAL OBSTRUCTION (DILATATION)

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GASTRODUODENAL obstruction is frequently overlooked because of the preponderance of acute intestinal obstruction in the soldier with abdominal wounds. Yet it is in the severely debilitated patient and the patient who has suffered extensive injuries that gastroduodenal obstruction is most likely to occur. It is important that the patient with these acute and subacute obstructions of the duodenum should be recognized, for his management and the ultimate prognosis are different from those of the patient with intestinal obstructions caused by adhesion bands and kinks. The significant points in the diagnosis and management are presented.

Although little known and recently even less discussed, there is nothing very new about the complex usually referred to as acute gastric dilatation. It was recognized by Duplay¹ as early as 1833. Von Rokitsansky² in 1842 described the fact that the duodenum could be obstructed by the root of the mesentery, producing an acute dilatation of the stomach. The mechanism was further brought out by Heschl in 1851, Glenard³ in 1887 and Albrecht in 1899 as well as Condon⁴ and Doolin⁵ in 1919. Erdmann⁶ in 1868 described the association of this complication with injuries and wasting conditions. Ladd in 1932 described (and in 1937⁷ further discussed) an obstruction of the duodenum due to a malrotation of the intestine and congenital adhesion bands, which was associated with a massive volvulus. Several reports of this type of obstruction, especially in infants and children, appear in the literature. Many articles and papers describing gastroduodenal ileus and associating it with postoperative and postpartum complications have been written since.

1 Duplay, A, quoted by Kellogg^{10b}

2 von Rokitsansky, C. *Lehrbuch der pathologischen Anatomie*, ed 3, Vienna, W. Braumüller, 1861, p. 187.

3 Glenard, F, quoted by Kellogg^{10b}

4 Condon, A. P. *Treatment of Acute Gastromesenteric Ileus*, *Ann Surg* 70 107, 1919.

5 Doolin, W. *Acute Dilatation of the Stomach*, *Brit. J. Surg* 6 125, 1919.

6 Erdmann, L. *A Case of Gastric Dilatation*, *Arch f path Anat* 53 295, 1868.

7 Ladd, W. E. *Congenital Duodenal Obstruction*, *Surgery* 1 878, 1937.

ETIOLOGY

Most modern authors feel that the point of obstruction in acute gastroduodenal dilatation is in the duodenum. In the postoperative patient there may well be an inhibition of gastric peristalsis, and in the patient who is an air swallower a certain amount of gastrectasia undoubtedly occurs. It is my opinion, however, that the severe symptoms which are associated with the syndrome as commonly described are almost invariably due to obstruction in the duodenum. The exact site of the obstruction is usually at the point where the superior mesenteric artery crosses the duodenum. Albrecht and Glenard have demonstrated that normally the duodenum is compressed at this point between the aorta and the mesenteric root.

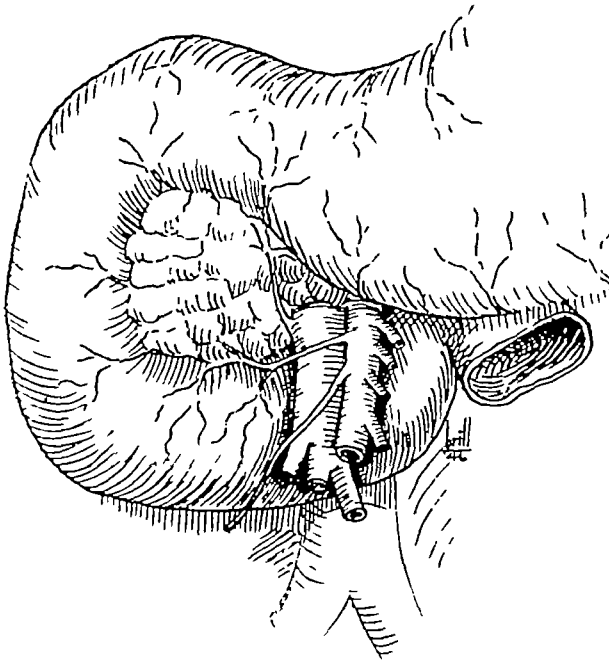


Fig 1—Diagram illustrating the relations between the duodenum and the superior mesenteric vessels. Note that the duodenum lies in a crotch formed by these vessels and the abdominal aorta. Normally the duodenum is indented at this point. Should the vessels be under a direct downward tension, the indentation may become a complete compression.

Predisposing factors include emaciation, ptosis of the viscera, a short mesentery, lordosis of the lumbar portion of the spine and collapsed intestines, such as are seen in wasting disease. A chronic obstruction of a mechanical type may be transformed into an acute one, as Kraas and I⁸ have pointed out in a previous publication. In 1 of the cases

8 Kraas, E, and Beck, W C. Chronic Duodenal Ileus, *Ann. Surg.* 99: 311, 1934.

discussed in this paper, a chronic obstruction remained two months after the acute obstruction had abated

INCIDENCE

It is difficult to estimate the incidence of this condition, especially in a series of wounded patients. The soldier is usually comparatively well nourished, and it is only the severely wounded patient who becomes emaciated. Also there are many cases in which the condition probably remains unrecognized and is treated as acute intestinal obstruction of lesser or minimal degree.

In civilian life the condition appears to be relatively frequent, if one judges from the extensive series collected. Connor,⁹ in a series of 131 cases, found that in 17 the condition followed trauma, in 71 it followed operations, in 43 it occurred during the progress of entirely unrelated diseases and in 9 it occurred during convalescence. My colleagues and I have observed 4 cases during the last seven months in which the conditions were severe enough to cause concern, and probably several others of more minor degree have been unrecognized. All our patients were bedridden, and all were of the thin asthenic type. Also, all had suffered extensive loss of weight as a consequence of their wounds. Two of the patients were immobilized on their backs by traction, and another was in a hyperextension jacket for a compound fracture of a vertebra.

SYMPTOMS

The most prominent symptom in our experience has been vomiting. This is copious in amount and is associated with nausea but with little retching. The fluid comes out frequently and in comparatively small amounts, which Kellogg¹⁰ described as a "spilling over of a distended organ." The vomitus is bile stained to dark green. If a stomach tube is introduced, there will be a remarkably large amount aspirated, usually over a liter. Pain, though present in most of our cases, is not a prominent feature. It is situated in the periumbilical area and does not radiate. It is colic-like in character but not severe and not associated with borborygmic sounds. Hiccup appeared transiently in 1 of our patients.

The physical findings were few in our patients. The abdomens were distended slightly above the xiphopubic level in 2 cases and were flat in the others. Abdominal tenderness was entirely absent, or it was diffuse and slight. We did not elicit a succussion splash. The bowel sounds were infrequent but present and normal in character. A

9 Connor, L. A. Acute Dilatation of the Stomach and Its Relation to Mesenteric Obstruction of the Duodenum, *Am J M Sc* **133** 345, 1907.

10 Kellogg, E. L. (a) Acute Gastro-Mesenteric Ileus, *Am J Surg* **13** 227, 1931, (b) The Duodenum, New York, Paul B. Hoeber, Inc., 1933.

wide area of tympany was found on percussion in 1 case, and this was associated with a definite reduction in the area of liver dulness

The more striking part of the physical examination was the general appearance of the patient, which was usually one of pronounced loss of weight and emaciation. In 1 of the patients the tongue was red and meaty, as in riboflavin deficiency. The patients were not too uncomfortable but were thirsty and apprehensive.

DIAGNOSIS

The roentgenogram is diagnostic. A scout film of the abdomen reveals pronounced dilatation of the first and second parts of the

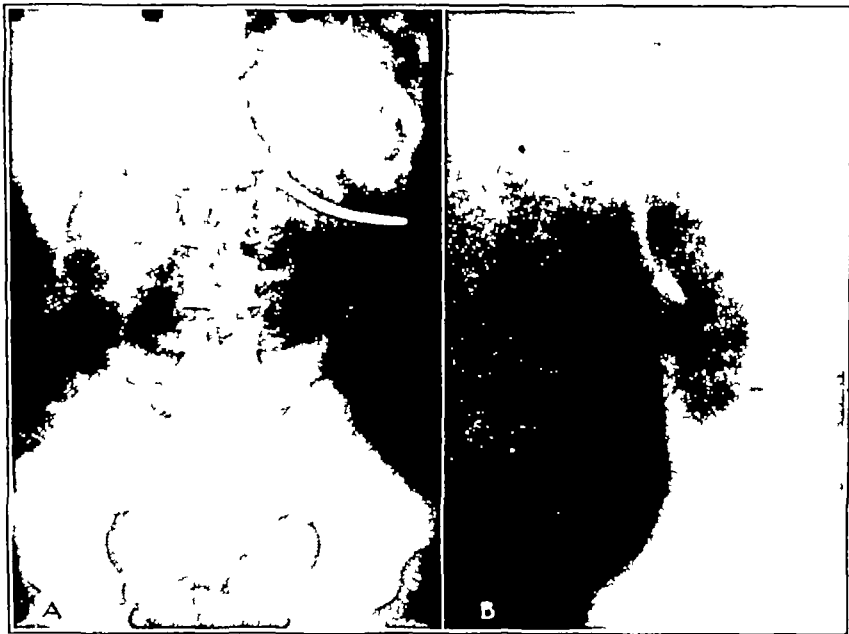


Fig 2—*A*, scout film of the abdomen in a patient with an acute gastroduodenal obstruction. The Levine tube is in the fundus of the stomach. Note the large gas shadow in the stomach. Note that there appears to be a second gas shadow which, although its contours are continuous with those of the stomach, is separate from it. This is a gas-distended duodenum (as proved in figure 2 *B*). *B*, lateral scout film. Note the two large gas shadows. The anterior one is the stomach, and the posterior one is the duodenum. This view proves the duodenal site of obstruction. The Levine tube appears to project into the duodenum, but this, as can be seen on close inspection, is not true.

duodenum. The anteroposterior roentgenogram should be augmented by a lateral roentgenogram. The duodenum lies on a different anteroposterior plane than the stomach, and the air dilatation of the duodenum then becomes completely visible in the lateral projection. We have found this test to be a conclusive one. All the roentgenograms must

be taken with the patient recumbent. The search for fluid levels is confusing and will contribute nothing to the diagnosis.

In the postoperative patient and in the patient who has been injured, acute intestinal obstruction will enter into the differential diagnosis most frequently. This is frequently true in the patient who has been operated on for abdominal wounds, for in this patient some degree of obstruction of the bowel at some time in his postoperative life is the rule rather than the exception. As so many patients respond quickly with Wangensteen suction and intravenous administration of crystal-



Fig 3—Gastrointestinal study of the same patient illustrated in figure 2, revealing a residual dilatation of the duodenum. This can be classified as a chronic duodenal ileus at this time. Although not sufficient time has elapsed to determine the permanency of this dilatation, it indicates further follow-up studies.

loids, the busy surgeon may miss the opportunity of taking a roentgenogram and may institute treatment for an obstruction of the bowel. This treatment will also benefit and may even cure the arteriomesenteric duodenal obstruction, so that the differentiation is not made.

It has frequently been noted that patients who have suffered a great loss of weight and are confined to bed will become nauseated and vomit when attempts are being made to replenish their nutritional

balance. Certain of these patients are suffering from mild gastroduodenal dilatation. When, indeed, their nutrition is corrected and they have gained weight, the duodenal obstruction is overcome and they are able to eat without difficulty. Proper recognition of this state will enable one, however, to avoid the period of nausea and vomiting. Peritonitis should be considered in the differential diagnosis in the early postoperative cases. In all these states the differential diagnosis is easily established by the use of the abdominal scout film in the anteroposterior and lateral projections.

TREATMENT

Once the diagnosis has been established, there are three aims to the treatment: (1) emptying the stomach and keeping it empty, (2) relieving the obstruction of the duodenum and (3) replenishing the lost electrolytes and maintaining the nutrition or correcting the emaciation. The first and most important step in the treatment in the acute case is to completely empty the stomach. This may be difficult to accomplish with the use of the simple nasal tubes of the Levine or the Wangenstein type, and one may have to resort to the use of the large caliber stomach tube. The comfort, however, achieved by the use of tubes of smaller lumens makes these the method of choice, although no tube smaller than 16 F should be employed. The openings in the tube should be large and many and the tube of fairly firm consistency. I prefer to watch the patient carefully for the first two hours after the tube is introduced, and if even for a few minutes there is no motion of the stream I insist that the system be irrigated in order to keep any obturation from blocking the tube. Once the stomach is empty, the tube is left in position, connected to a suction apparatus. At the end of twenty-four hours, the tube is clamped for periods starting with ten minutes and gradually increasing, each time the amount of material which collects in the stomach is observed. At first it will be noted that the amounts are rather large. When one discovers after a two hour interval that there is but little residue, the obstruction has been removed.

The most important factor in the reduction of the obstruction is the maintenance of an empty stomach. The second is the correction of the nutritional status of the patient. Certain other methods of correcting the arteriomesenteric compression have been described, and some may be tried. Kellogg¹⁰ suggested the use of an abdominal binder tightly applied over a pad situated just above the symphysis pubis. I have not found that this gives any startling results, and it is uncomfortable to an already much harassed patient. He further recommended that the patient assume a knee-chest position, with abdomen supported on pillows. This has been impossible in my cases. It is of

definite help in the subacute cases and may be helpful in the later stages, in which the patient is able to eat. Elevation of the foot of the bed appears to be of value.

The replacement of the electrolytes and the combating of the alkalosis are obtained by the accepted methods in use in the treatment of obstruction high in the bowel. The epochal work by Haden and Orr¹¹ as well as the many writings of Collier and his associates have put the fluid and electrolyte replacement technic on a firm basis. Control of the situation is checked by studies of chloride and carbon dioxide-combining power of the blood. The replacement of the upset nutritional balance is far more difficult. Parenteral methods are of comparatively little value, for the amount of food so administered is barely enough to maintain the daily requirements, to say nothing of the already great deficiency of protein and carbohydrate. Therefore, as soon as possible, certain concentrates should be permitted by mouth. This may best be accomplished by the use of either an intragastric drip or gavage at intervals through the suction apparatus (which is clamped for varying periods after the introduction of food which is largely protein and carbohydrate). Too much fluid should not be administered with the food, just enough to afford a semiliquid consistency which will pass through the tube. In this way, only small amounts will be given. The fluid balance can be maintained by parenteral means. The protein metabolism may be watched and controlled by the observation of the renal nitrogen output. Weak solutions of alcohol are worth while.

Thus it is observed that the therapeutic methods are all interrelated and complementary. The emptying of the stomach to a certain extent relieves the obstruction, and the replacement of the nutritional deficiency does the same.

In the cases of milder conditions, in which it is not necessary to empty the stomach, the assumption of the knee-chest position and the use of small frequent feedings, a continuous drip gavage even being resorted to, may benefit the patient to such a degree that in a few days he will be able to eat normally.

Operative intervention, with the performance of a duodenojejunostomy, is rarely if ever indicated in acute duodenal ileus except in the cases described by Ladd, in which a volvulus or congenital bands make the operation imperative.

PROGNOSIS

In the older literature and indeed until not many years ago, the prognosis of acute gastroduodenal obstruction was extremely poor.

¹¹ Haden, R. L., and Orr, T. G. The Effect of Inorganic Salts on the Chemical Changes in the Blood of a Dog After Obstruction of the Duodenum, *J. Exper. Med.* 39: 321, 1924.

Connor in 1907 reported a mortality of 72 per cent, and Laffer¹² in 1908 reported 63 per cent in 217 cases. At present, the mortality is probably so low that the medical student and the intern in recent years have probably never heard of the condition which caused their predecessor generation much fear and worry. The treatment today is, by and large, so successful that the diagnosis is missed. Nevertheless, the recognition of the fact that the patient has an arteriomesenteric obstruction will permit one to effect a more rapid cure and to assure the patient that he will not suffer a repetition of the condition, which is far more than one can say for obstruction of the bowel caused by adhesions.

On the other hand, there may be the patient who will retain a chronic duodenal ileus, and his management will be far better and his complaints more readily understood if the surgeon realizes that such a patient should have another roentgenogram made at a later date for evidences of duodenal dilatation. The percentage of patients in whom a chronic duodenal ileus will develop after an acute episode is not known. None of the large series reported have any follow-up studies. In 1 patient we have observed there was a definite duodenal dilatation two months following the original episode. The patient, however, had no subjective complaints. Should he later have symptoms, he probably will not give the present acute lesion any thought and the past history may not be noted. From 1 of our patients with an acute lesion we obtained a history of a previous similar episode when he was bedridden for a considerable period with pneumonia. Between these episodes he had had chronic gastrointestinal complaints, for which he had once been hospitalized, but no diagnosis was established at that time.

Thus it appears that the patient who has had an acute arteriomesenteric duodenal obstruction should be observed and studied when he has recovered. It would be wise to instruct him that when he is bedridden for any length of time he should warn the physician of this experience and thus may be spared a repetition. In 1 of our patients after recovery from his acute phase an acute appendicitis developed. The possibility of a relapse being realized, he was treated with constant intragastric suction for twenty-four hours postoperatively, at which time he could sit up with a high back rest. Neither nausea nor vomiting developed, and he had an uneventful postoperative course.

SUMMARY AND CONCLUSIONS

1 Acute gastroduodenal dilatation is usually due to an obstruction of the duodenum by compression of this organ between the superior

¹² Laffer, W. B. Acute Dilatation of the Stomach and Arteriomesenteric Ileus, *Ann Surg* 47 390, 1908

mesenteric artery and the vertebral column and aorta. It occurs in the debilitated or emaciated patient who is forced to lie on his back.

2 The diagnosis is made on the symptoms of continuous copious vomiting and is confirmed by the roentgenographic scout film. A lateral roentgenogram establishes the diagnosis of the site of the obstruction in the duodenum.

3 The treatment is aimed at keeping the stomach empty, relieving the obstruction and replenishing the deficiencies in electrolytes and nutrition.

4 Before the patient is discharged from treatment, a careful roentgenologic study should be carried out to determine whether a chronic duodenal ileus is still present.

REPAIR OF RUPTURES THROUGH THE LARGER TENDONS BY REMOVABLE STAPLE SUTURE

A Preliminary Report

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THE use of a 'distant, bolt, retention or staple suture' for decreasing tension at the site of a surgical repair is a well established procedure. It has been used extensively for prevention of evisceration in abdominal wounds by Auchincloss¹. It has brought operations on tendons to peak efficiency in the hands of Bunnell². The latter author recently has contributed an additional feature to the suture by making it removable even when implanted into a tendon. This feature has increased its efficiency and adaptability immeasurably and makes logical his suggestion that it be used for repair of the larger tendons. As a result of the stimulus of his work, the procedure has been used in the fracture clinic of the Presbyterian Hospital in New York for repair of achilles, quadriceps and triceps tendons. The results to date compared with results of experiences with previous, more orthodox methods of repair have proved so satisfactory that a preliminary report is presented in the hope that it may stimulate a more widespread use of this efficient and adaptable principle.

Rupture of the larger tendons is neither common nor likely to be encountered except in a patient past the age of 45. At earlier ages rupture is apt to be incomplete and temporarily amenable to conservative therapy. After such an incomplete tear is healed, subsequent function of the tendon is accompanied by a constant risk of rupture through the remaining intact fibers. Complete rupture requires surgical repair. This is true despite the fact that the rupture may result from relatively insignificant trauma. The characteristic ease of rupture is usually the result of localized weakness in the tendon at the site of a previous incomplete rupture, local degenerative change or, more often, both.

From the fracture service of the Presbyterian Hospital in New York and the Department of Surgery, Columbia University College of Physicians and Surgeons

1 Auchincloss, H. Drainage and Wound Closure Technique in Appendicitis Operations, *Ann Surg* **116** 435-444, (Sept) 1942

2 Bunnell, S. Surgery of the Hand, Philadelphia, J. B. Lippincott Company, 1944

The relative ease and efficiency of early as compared with late repair is beyond argument. Even early repair frequently is characterized by considerable difficulty, resulting from the pathologic changes predisposing to rupture. It almost always is apparent that the tear has taken place through abnormal tendon tissue, marked by gross degeneration and fibrillation of the fibers, at times scar tissue replacement of previously ruptured fibers and occasionally neoplastic change. The surgeon is confronted with a situation in which he is required to join two tendon fragments, the apposing ends of which are frayed out into strings of friable, avascular and degenerated tissue. Healthy tendon may not be encountered for a considerable distance proximal and distal to the level of the rupture. Excision of this degenerated tissue is necessary before healthy tissues become available for repair. Excision produces tension on the suture line in direct proportion to the amount excised. Tension reduces local tissue resistance to infection, predisposes to disruption of the repair and makes postoperative immobilization, often in a poor functional position, almost always imperative. All these factors prolong convalescence and tend to detract from the quality of the eventual result.

Late repair is much more difficult. Maximum retraction of the proximal fragment is the rule. The retracted position is maintained by contracted muscle bellies that have lost their elasticity and become adherent to adjoining structures. In addition, the avascular tendon fragments curl up and become solidly enmeshed in a mass of scar tissue, which requires extensive and at times bloody dissection before the ends of the tendon can be mobilized. Apposition of the ends is always difficult. At times it is impossible, so that the gap requires bridging by fascia. No matter whether direct or fascial repair is carried out, immobilization, with all its inherent disadvantages, is usually a constant postoperative requirement in the management of old, long-standing lesions.

The general prerequisites for ideal repair of the tendons include (1) apposition of healthy to healthy tendon tissue, (2) minimum tension at the site of repair, (3) minimum foreign material at the site of healing and (4) minimum interference with normal function during the period of healing. The first three have to do with the quality of the eventual result, and the fourth, more than anything else, governs the speed of recovery. Simultaneous attainment of all four requirements has been accomplished most nearly by a removable traction suture, used in a manner to be described in the following report of cases.

REPORT OF CASES

CASE 1—*Complete rupture of the patellar tendon (four months' duration)*

M. O., a 60 year old man, was admitted with a history of misstep and injury to his right knee four months before. The knee temporarily was strapped by

his family doctor. In spite of this support the patient complained of increasing pain and limp, and these symptoms continued until about six weeks prior to admission. At that time he slipped on some ice and reinjured the knee. From then on he had to use a cane to get around, suffered from a pronounced limp and complained of inability to straighten the bent knee against gravity and of intermittent "buckling" and pain in the joint.

Examination of the extremity demonstrated a complete absence of extensor power at the knee, although the quadriceps muscles could be felt to contract and tug on the patella with attempted extension. These muscles were extremely atrophic and atonic. The patella rested at a level 3 inches (7.6 cm) more proximal than that of the normal extremity. A palpable transverse sulcus was present between the patella and the tibia. This could be felt to extend through the infrapatellar tendon into the adjoining vastus expansions. Passive motion at the joint was unlimited. Roentgenograms confirmed the presence of a retracted patella but were otherwise normal except for pronounced disuse osteoporosis of all the bones.

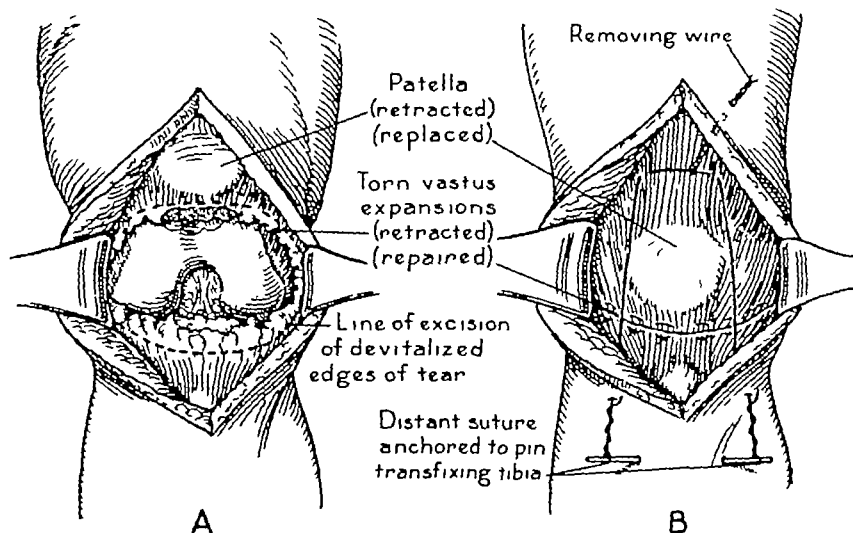


Fig 1—*A*, pathologic changes in rupture of the patellar tendon in case 1
B, repair of this rupture by removable staple suture

A diagnosis of rupture through the patellar tendon and its adjoining capsular and tendinous expansions was made and repair advised. From the history, it was concluded that the patient had suffered a partial rupture four months previously and had completed the lesion at the time of his second mishap.

At operation, the following pathologic changes were encountered (fig 1*A*). A complete rupture of the patellar tendon existed. On either side, the tear extended through the adjoining vastus expansions as far medially and laterally as the level of the collateral ligaments. A hiatus of 5 cm was present between the separated fragments of the tendon. The proximal fragment of the tendon was about 2 cm in length, with its curled up and rounded end completely enclosed in an irregular globular mass of scar tissue. The distal fragment was similarly enclosed in a cicatrix, with the fat pad firmly attached to its deep surface. The torn edges of the vastus lacerations were rounded off and covered by smooth adult fibrous tissue. The remaining intra-articular structures were approximately

normal except for diffuse thickening, edema and extreme friability of all tissues in the neighborhood of the lacerated structures

Excellent exposure was obtained through a long median parapatellar approach. With the pathologic changes fully exposed and a bone hook placed in the patella for traction, considerable force was required to approximate the separated tendon ends. After excision of the scarred ends of each fragment at a point indicated by the broken line (fig 1A) and mobilization of the proximal fragment by excision of the adhesions binding it to surrounding structures, reapproximation was fairly easy but maintenance of position still required more force than was considered possible and safe by direct suture of the friable ends of the tendon. A staple suture of stainless steel wire therefore was placed through the quadriceps tendon, just proximal to the patella (fig 1B). By traction on the free ends of this suture, the patella and the proximal fragment of the tendon were pulled down to the desired level with relative ease. The ends of the suture were then brought out through separate stab wounds and fastened to a rigid pin, which had been passed through the tibia just below the distal extremity of the operative wound. Pin anchorage of this type was used for a purpose identical to that of Bunnell's buttons. Owing to the considerable force required for maintenance of position against a group of muscles as strong as those attached to any of the larger tendons, anchorage by button, with pressure on the skin, is not considered feasible.

With the staple suture in place, the freshened ends of the torn fragments lay loosely apposed to each other. Six apposition sutures of fine silk were placed to insure a snug approximation of the tissues at the site of healing. A removing wire was then passed around the proximal extremity of the staple suture and brought out through another stab wound (fig 1B). At this point, with repair accomplished and the wound ready for closure, it was noted with satisfaction that the total of foreign material at the site of repair consisted of only six fine sutures. No foreign material was left in the joint cavity. The staple suture lay between subcutaneous tissue and fascia. Gentle attempts at flexion were done prior to closure, and it was found impossible to place any significant strain on the repair site with flexion to 150 degrees, although this produced considerable tension on the staple suture proximal to the patella. The main wound was then closed and the stab wounds sutured snugly around the emerging wires.

The patient was returned to bed and the leg placed in balanced suspension. During the first week following operation, it was noted that the patient could utilize quadriceps function and hold the leg extended against gravity via the staple suture connection between quadriceps tendon and tibial pin. After ten days, gravity-free motion was allowed within supervised limits (180 to 150 degrees). After a few days of this program, it was noted that the tension on the staple suture decreased perceptibly. This was considered to be the result of gradual return of elasticity in the quadriceps muscle bellies, and the ends of the suture therefore were unwound from the transfixion pin and reattached more tautly. The wounds healed per primam and with less local reaction than wounds of similar nature in past cases. On the twentieth postoperative day a plaster encasement was applied to the extended leg from groin to ankle, incorporating the protruding ends of the tibial pin. The patient was discharged, walking without other support, on the twenty-eighth postoperative day. It may be said that interest and relative uncertainty concerning a patient treated in this way for the first time prolonged his hospital stay by a considerably longer time than the local condition demanded.

After discharge the patient was followed at weekly intervals and found to be incapacitated a surprisingly small amount. His locomotion was comfortable and adequate enough in amount to warrant expectation of steady rehabilitation of the quadriceps muscle. In addition to ordinary walking, a program of quadriceps-setting and straight leg-lifting exercises was carried out, and the patient was soon able to lift both leg and plaster against gravity with ease.

Eight weeks following repair, the plaster encasement was removed. No reaction was present at any of the wire or pin holes. The tibial pin was removed and the free ends of the staple suture cut flush with the skin at their point of emergence. Traction was then placed on the removing wire, and an error in operative technic immediately became apparent. The removing wire had been placed around the proximal extremity of the staple suture and its free ends brought through the skin without twisting. During its eight weeks' stay, healing tissues had grown into the interval between the two limbs of the suture so that it was found impossible to remove it until enough traction was applied to break down this impediment. As a result, it subsequently has been considered important that the removing wire be twisted as tightly as possible at the time of insertion, for prevention of similar difficulties.

Immediately after removal of the staple suture, the patient was able to maintain 175 degrees of extension and to flex and extend the leg against gravity through an arc between 175 and 125 degrees, with ease and comfort. The quadriceps muscles were in good condition. The patient was allowed to walk without any support other than a cane. The cane was necessary not because of the knee condition per se, but because of generalized mild unsteadiness and signs suggestive of the early stages of paralysis agitans. For a few weeks the patient experienced mild local difficulty in going upstairs and downstairs, but six weeks following removal of fixation this difficulty had disappeared. At this time he reported ability to walk a mile (1.6 Km.) at a time, without trouble, the knee was stable, with full passive and an active range of 175 to 70 degrees against gravity, and the patient was asymptomatic except for local swelling each evening. When last examined, nine months following operation, the knee was objectively and subjectively normal as compared with the other leg.

This case represents the first instance at this clinic in which it has been possible to maintain active muscle function, including ambulation, during almost the entire period of healing following late repair of a complete rupture of the patellar tendon and its adjoining aponeuroses. The technical details of the repair were simple, and difficulties encountered in previous similar lesions were overcome with ease. The requirements for ideal repair of the tendon were more nearly attained and functional recovery was sooner and to date more complete than by any method of repair previously employed.

CASE 2³—*Bilateral rupture of tendo Achillis (five days' duration)*

A R., a healthy 49 year old man, had been an athlete and done considerable track work as a sprinter while in college. His leg muscles always had been better than the average. In 1942 he had been laid up for four days, after having had his left calf squeezed between the bumpers of two cars. The diagnosis was partial rupture of the gastrocnemius muscle belly. Three days prior to the present admission, he sprinted to catch a train. Suddenly, on successive steps,

3 Case 2 is included in the study through the courtesy of Dr. William Darrach.

he felt a sensation of something giving way with an audible snap just above either heel. From that time on he was able barely to hobble around and when doing so suffered from a constant sensation of being about to fall forward.

Examination showed mild swelling and edema distal to the midpoint of both calves. Faint ecchymoses were present in the postmalleolar sulci. A palpable slightly tender transverse hiatus was present in each achilles tendon, about 3 inches (7.6 cm) proximal to its point of insertion into the os calcis. Contraction of the calf muscle accentuated these defects. Little or no power of plantar flexion was available at either ankle. The diagnosis of bilateral rupture of the tendo Achillis was beyond question.

The following gross pathologic changes were noted at operation, which was carried out within forty-eight hours. A complete rupture of the tendo Achillis was present on both sides—on the left 5 cm and on the right 7 cm proximal to the point of insertion into the os calcis. On both sides there was extreme shredding (fig 2 A) of the tendon, so that the torn area occupied 7 cm of the

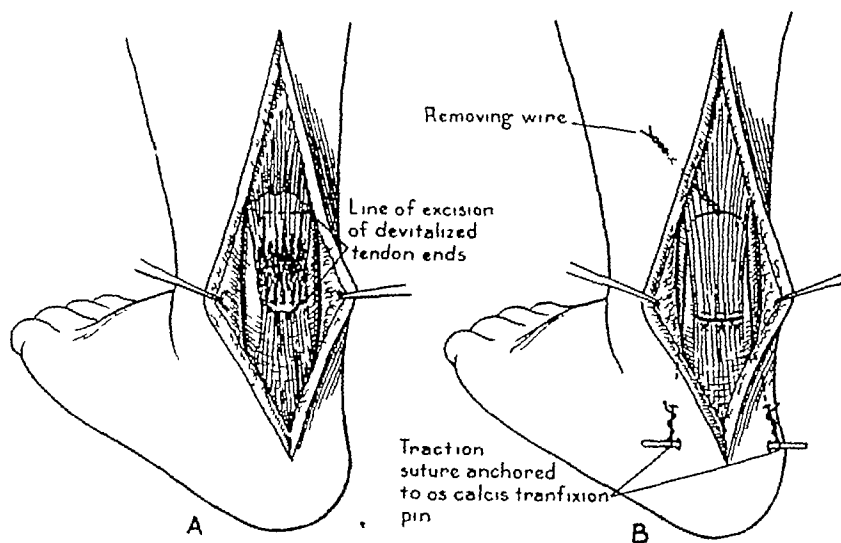


Fig 2—A, pathologic changes in rupture of achilles tendon in case 2. B, procedure in repair of rupture by removable staple suture.

length of the tendon. On both sides the lacerated tendon was surrounded by old blood clot, held in place by the loose areolar tissue.

Identical procedures were carried out bilaterally (fig 2 B). A midline incision was deepened to expose the pathologic changes of the tendon. A stainless steel wire was passed transversely through the tendon at a point 5 cm proximal to the upper margin of the shredded area. A stiff steel pin was passed through the os calcis. Traction was then placed on the free ends of the wire and the proximal tendon fragment pulled distalward until all retraction had been overcome. This was accomplished with ease because of the short duration of the lesions. Traction was then released and the ends of the tendon freshened by excision of obviously devitalized and avascular portions of the shredded tissues. The free ends of the wires were then passed through the subcutaneous tissues and brought out through stab wounds on either side of the incision in the skin. Traction was reapplied until the ends of the tendon lay in close approximation and the ends of the wire twisted around the steel pin (fig 2 B). Dorsiflexion of the

foot to 80 degrees was then possible without separation of the unsutured fragments of the tendon, although considerable tension was noted on the wire staple suture. Approximation of the ends of the tendon was insured by several fine silk sutures and the main wound closed in layers

After operation the patient was allowed to lie in bed without any additional support. The emerging wires and pins were kept covered within the one large dressing used for the operative incision. Within a few days the patient was encouraged to move his ankle joints within pain limits. The wounds were dressed and found to be healed per primam on the eleventh day, and the patient was allowed home one week later. Walking was not allowed, and during the next three and one-half weeks he got around his home by wheel chair.

Six weeks following repair, the fixation apparatus was removed. Owing to an oversight at the time of operation, no removing wires had been inserted. However, after removal of the os calcis pins and cutting of the staple sutures where they emerged from the skin, both the latter were removed with ease, the transverse portion being grasped with a clamp inserted through a 0.5 cm incision in the overlying skin. The patient was allowed to commence ambulation with crutches at this time. Two weeks later resisted plantar flexion was strong and without pain, the regions of tendon repair felt firm and the patient was allowed gradually to resume normal walking. When last examined, six months following operation, he complained of no symptoms referable to the tendon repairs and was playing 18 holes of golf one to three times a week without difficulty.

It goes without saying that despite the mechanical advantages of the repair described in these cases there are also certain disadvantages. Some uncertainty was felt concerning the possibility that the proximal portion of the staple suture might cut through the tendon when subjected to the force exerted by the strong muscles involved. Examination on the operating table, with passive strain produced by the surgeon, and observation of the postoperative clinical behavior of these patients indicated that this danger is unimportant providing that motion of the repaired structures is kept within pain limits and the repair protected against external forces. For this reason it is not considered advisable that the retention suture be woven back and forth through the tendon in the manner described by Bunnell. Such may be the procedure of choice when fine wire is used for repair of the small tendons. The heavy wire required for retention of the larger tendons may present difficulties in extraction if woven.

The one obvious defect in the procedure as described is the risk of introducing infection at one of the sites of emerging wires or pin. Various ways of decreasing this risk present themselves in the light of a still small clinical experience and are contemplated for use in subsequent cases.

The bilateral lesions of the tendo achillis in which the insertion of removing wires was overlooked until after the wound was closed proved that removing wires were unnecessary. An ordinary clamp inserted through a tiny cutaneous incision served the purpose of removing the staple suture well, and thereby one potential port of

entry for organisms during the healing period was eliminated. Experience may prove a small cutaneous nick and the insertion of a clamp to be much the safer and wiser method of removing the staple suture. If removal is to be done by clamp, however, care must be taken at the time of operation to see that the most proximal transverse portion of the staple suture lies on the superficial surface of the tendon and is available for easy grasp by the removing clamp. It might also be advisable to mark the skin at the exact level of this transverse portion of the wire prior to closure of the operative wound. Such a mark would simplify localization of the suture when the time for its removal arrived.

Elimination of the removing wire leaves four potential ports of entry for infection. Two of them are unnecessary. At elbow, knee or ankle it is easily possible to thread the ends of the wire through the subcutaneous tissue plane so that they emerge from the skin through the same stab wound as the transfixion pin. At this point they may be twisted around the pin, not only eliminating their previous individual points of exit but also insuring that the only two remaining points of danger remain a considerable distance from the operative site. If post-operative active motion within pain limits is to be allowed following repair, as it should be, any reduction in the number of points at which the wires emerge through the skin would seem to be of considerable import.

CASE 3—Rupture of the olecranon and triceps tendon (one day's duration)

M. F., a healthy 14 year old boy, was admitted one hour after sustaining an injury to his left elbow. Local examination showed a rapidly increasing area of soft swelling in the region of the olecranon, through which it was difficult to palpate bony landmarks. There was no history suggestive of reduced dislocation, the nerves and circulation distal to the elbow were functionally intact and the antecubital fossa showed no evidence of pathologic change. There was complete absence of power to extend the elbow against gravity. Roentgenograms confirmed the clinical impression of a fractured and retracted olecranon. The proximal fragment was seen to be composed of the olecranon epiphysis and a small fragment of metaphysis, with about 2.5 cm. of separation from the parent bone.

Operation was done within a few hours. Examination of the pathologic changes revealed a condition illustrated in figure 3A. The small proximal fragment of olecranon was retracted about 3 cm. by the main tendon of the triceps. This retraction was made possible by a rent through the substance of both triceps expansions, extending 3 cm. through the lateral and 2.5 cm. through the medial expansion. In the depths of the cavity, the olecranon fossa and the posterior articular surface of the humerus were in full view and free from visible evidence of damage.

Reparative sutures were placed in a manner depicted in figure 3A. Stainless steel wire was used for the main retention suture, which was to hold the bone fragment and main body of triceps tendon in place, and fine silk sutures were placed mattress fashion in the lacerated tendon expansions. It was then decided to try to make the main foreign body (the steel wire) removable. Although

removal of such sutures from the region of the olecranon is not commonly required, it was considered that providing it could be done safely any reduction in the operative procedure necessary for removal would be an advantage. In order to accomplish this, the main wire at point *a* in figure 3 *B* was twisted rather than tied.

Four twists were taken in the wire and noted on the record for purposes that will be apparent at the time of removal. A twisted removing wire was then placed around the most proximal transverse portion of the wire suture at point *b* (fig 3 *B*). The ends of both twists were left projecting toward the skin, which was closed over them as in figure 3 *B*. After closure of the operative incision, the twisted wires, while not projecting, were readily palpable through the skin.

After operation the patient was allowed active motion of the arm. After five days a defect in operative technic was discovered, when it became apparent that if motion were continued the wire twists might work their way through the skin from within. It was obvious that in order to prevent this in future cases the

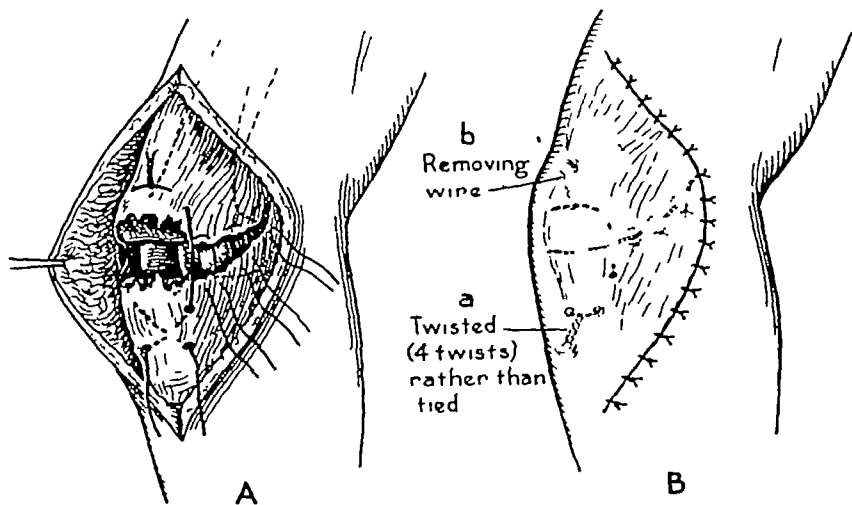


Fig 3—*A*, placement of sutures in repair of the olecranon and the triceps tendon (case 3). *B*, main wire (*a*) for suture in case 3 is twisted rather than tied. A twisted removing wire is placed around the most proximal transverse portion of the wire suture (*b*).

twisted wire ends would have to be made shorter or bent so that they did not actually press against the deep surface of the skin. With such an amendment to the procedure as described, it was felt that the patient might have been allowed the active motion and use that should mark the postoperative program in all such cases. Inasmuch as this particular patient was not an adult it was felt that immobilization would do no significant harm, and a molded splint was applied to prevent further motion. Sutures were removed on the seventh postoperative day, and the wound was found to be clean and healed per primam. The patient was allowed home the next day.

The splint was maintained in place for a month from the time of repair. It was then removed, and, with the patient under procaine hydrochloride anesthesia, a small nick was made in the skin over each of the palpable wire twists. At twist *a* a clamp was inserted through the cutaneous nick and the wire grasped and

untwisted four complete turns (see operative procedure) Through the other cutaneous nick, twist *b* (fig 3*B*) was grasped with another clamp and the whole suture removed The boy went home and returned three days later to report that he had been playing baseball Ten weeks following operation he was enjoying full activities, without symptoms of any kind Examination of function revealed a defect of 5 degrees in extension and 10 degrees in flexion, with full rotation in both directions

As originally stated, the object of this preliminary report is to substantiate and concur with Dr Bunnell's suggestion that distant traction suture, as a principle, presents distinct advantages in the repair of ruptures of the larger tendons Many methods for the application of this principle are available Several have been described, along with the easily avoidable technical errors committed in their use for the first time in this clinic This report is not presented for the purpose of establishing or even advising the technics used but merely to illustrate some of the adaptable features of the principle which make its use in many avulsion lesions of the tendons and bones worthy of consideration

PLAN FOR THE CARE OF PERIPHERAL NERVE INJURIES OVERSEAS

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EARLY operative procedures on traumatized major peripheral nerves have been made possible during World War II by the improvement made in management of wounds, which under the present program results in more than 90 per cent of soft tissue wounds being well healed within three weeks from the time of injury. Scar formation is thus materially reduced about the injured nerve. This facilitates exposure, aids in the gross interpretation of the pathologic status of the nerve and eventually lessens the bed of constricting scar about the suture line. Infection is uncommon in the uncomplicated wound, and thus the necessity for delaying six months or more before repairing the nerve is obviated.

The present method of handling the injured nerve requires close cooperation of the forward and the base surgeons, by whom a well understood plan must be integrated. Each phase of care of wounds must be accurately completed if the next is to be successful.

DIAGNOSIS

Each extremity which suffers a soft tissue injury should be examined for nerve injuries at the forward hospital before the wound is debrided. The operating surgeon should be acquainted with the muscle actions of the principle nerves. For example, adduction of the extended thumb against the metacarpal-phalangeal region of the index finger and closure of the interphalangeal spaces of the fingers are impossible if the ulnar nerve is paralyzed, holding of the extended thumb at right angles to the palm in the opponens position cannot be done when the median nerve is paralyzed. Wrist drop and inability to abduct and extend the thumb on a plane with the palm indicate injury to the radial nerve. Inability to dorsiflex the foot and great toe signifies injury to the peroneal nerve, while failure to plantar flex the foot and great toe indicates paralysis of

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the tibial nerve When the extremity is encased in plaster it is difficult to test the motor power of the nerve in question, and if there is extensive damage to the muscle, injury to the bone or pain the patient may be unable to cooperate beyond response to pinprick Then the sensory findings are invaluable and must be mapped out with patience on the part of the examiner, particularly for an uncooperative patient If the hand or foot is edematous or cyanotic, the value of sensory changes will be materially lessened This bit of quickly obtainable information is of value preceding débridement, for if the nerve is paralyzed an attempt should be made to inspect it

IDENTIFICATION OF THE LESION

It is of considerable importance to visualize the entire lesion at the time of debridement and to record accurately the type and the extent of the lesion If early operation on the nerve is to be done, it is important to know whether it is severed, bruised, wedged or normal in appearance In the greater number of débridements the injured nerve can be inspected without extension of the incision The surgeon, by recording that a nerve has been completely or partially severed or contused, passes on invaluable information to the person who will later perform the definitive repair For example, one of the most important problems in this respect pertains to the contused nerve, in which severe intraneural hemorrhage and softening occurs quickly, resulting in the formation of "neuroma in continuity"

Early exploration of the completely paralyzed nerve which has been recorded as being intact is seldom indicated Time for spontaneous recovery should be allowed proportional to the level of the lesion However, if a neuroma is found by palpation or inspection, only excision and suture of the nerve will reestablish the pathway In such a case much valuable time would be lost in waiting for spontaneous return of function Exploration should be carried out within two months of the time of injury

Should proper description of the injured nerve be lacking in the initial operative note, the paralyzed nerve should be exposed at the time of secondary suture and the type of injury noted, providing this does not necessitate extensive dissection This has now been done in a sufficiently large number of cases to indicate that wound healing is not retarded or the incidence of infection increased

CARE OF THE NERVE AT THE TIME OF WOUND DEBRIDEMENT

After identification of the severed ends, various types of sutures were placed through the ends to bring them into relative approximation to prevent retraction and to fix them into the neighboring tissue for later identification purposes With further experience, it was observed that

these sutures increased the amount of fibrosis within nerve ends and were of negligible help to the operator in subsequent identification. The ends, after being examined, should be placed beneath the proximate muscles for protection. If proper splinting is done, there is little retraction of the nerve within the four or five weeks prior to neurorrhaphy.

IMMEDIATE NEURORRHAPHY

Primary suture of nerves in forward hospitals has not been widely practiced, although in two installations a number have been carried out successfully. Cases selected have been confined to those of relatively small, clean, uncomplicated wounds which could be closed primarily and to those in which it has been possible to keep the patient at the same hospital for at least ten days. In some instances, only the muscle or the fascia was closed over the suture line. The subcutaneous tissue and the skin were sutured four or five days later. Complete closure of the wound is preferable and can usually be done. During busy periods it is unwise to undertake formal suture, because of the time involved both for the operator and for the operating room.

Definitive repair of nerves is most safely done at installations in the Zone of Communication or in the United States three to five weeks following successful secondary closure. By that time the soft tissue wound should be well healed, the edema of the nerve ends should have subsided and the general condition of the patient greatly improved. Swelling and friability in traumatized nerve ends preclude formal suture much earlier than thirty days, even though the wound is cleanly healed before that time.

GROSS PATHOLOGIC CHANGES

When observed at initial debridement several hours following injury, nerve ends show little evidence of edema, though there may be moderate hemorrhagic discoloration near the ragged ends. At that time the nerve retains its elasticity and, though severed without segmental defect, the ends may be found 2 or 3 cm apart. This is an entirely different picture from that observed four or five days later, after the reaction to injury has become grossly apparent.

Because of insufficient observations made at the time of the debridement, more and more nerves have been inspected between the fifth and the tenth day following injury. Careful examination of the nerve discloses pronounced swelling and thickening of the epineurium extending for variable distances, with early adhesions to the surrounding tissues. Hemorrhagic discoloration is seen beneath the epineural surfaces, though there are more dilated epineural vessels than seen initially. Study of cross sections shows much less distinct fasciculi, with organizing bits of blood clot on the surface. The diameter of the nerve has increased by about one half. There is early bulbous swelling which is more pro-

nounced on the side of the impact. Thus if definitive suture were to be done during this period of acute to subacute reaction (which seems to last between two and three weeks), there is inability to judge accurately the amount of nerve to be sacrificed.

During the fourth and fifth week after injury, an entirely different pathologic picture is presented. Extreme epineural fibrosis has occurred, resulting in thickening of the epineurium, sometimes as much as 5 mm, which is stuck to but easily separates from the surrounding muscle. The epineurium is grayish white, and, except for the main nutrient epineural artery, large blood vessels are not conspicuous. A bulbous neuroma is present on the large proximal segment of nerve, and its cross sectional surface is dull and gray and lacks the well defined outline of the fascicular bundles. The distal glial-ended segment is much smaller and tends to point at its end and become lost in the surrounding new connective tissue. Its epineural thickness is less than that on the proximal side, and the whole segment seems to show less reaction. Palpation of each segment will now reveal differences in the consistency of the normal nerve from that portion involved in scar. In this way some indication may be obtained of the extent of the terminal segments which will have to be sacrificed. On the other hand, it is necessary to resect back until sharp-edged, well rounded glistening fasciculi are reached. Definitive suture is much easier and the functional results should be better when done during this period.

MICROSCOPIC CORRELATION

The gross appearance of the cross-sectioned level interpreted as being free of scar and suitable for anastomosis is often belied by the microscopic sections.

The epineurium is thickened, and fibrosis is well advanced, containing well organized capillary vessels. The perineurium may also be thick, and the interneural tissue contains evidence of chronic inflammatory reaction in the form of collections of lymphocytes and foreign body giant cells. Disorganization of the neural elements within the perineural framework is sometimes pronounced. Scattered between well formed axons are irregular zones of fibroblastic activity which compress and replace the nerve fibers. Hyperplasia of the axons is evident here and there. Here also are small collections of lymphocytes and giant cells. Figure 1 shows a cross-sectioned level unsuitable for anastomosis, while figure 2 shows that all evidence of scar and reaction to trauma has been removed, making this level satisfactory for suturing. Reliance on the gross appearance of the cross section seems unreliable, as all histologic evidence of inflammatory reaction and fibrosis should be absent at the level of anastomosis. Failure to resect back to such a level must certainly account for a substantial number of poor results or failures.

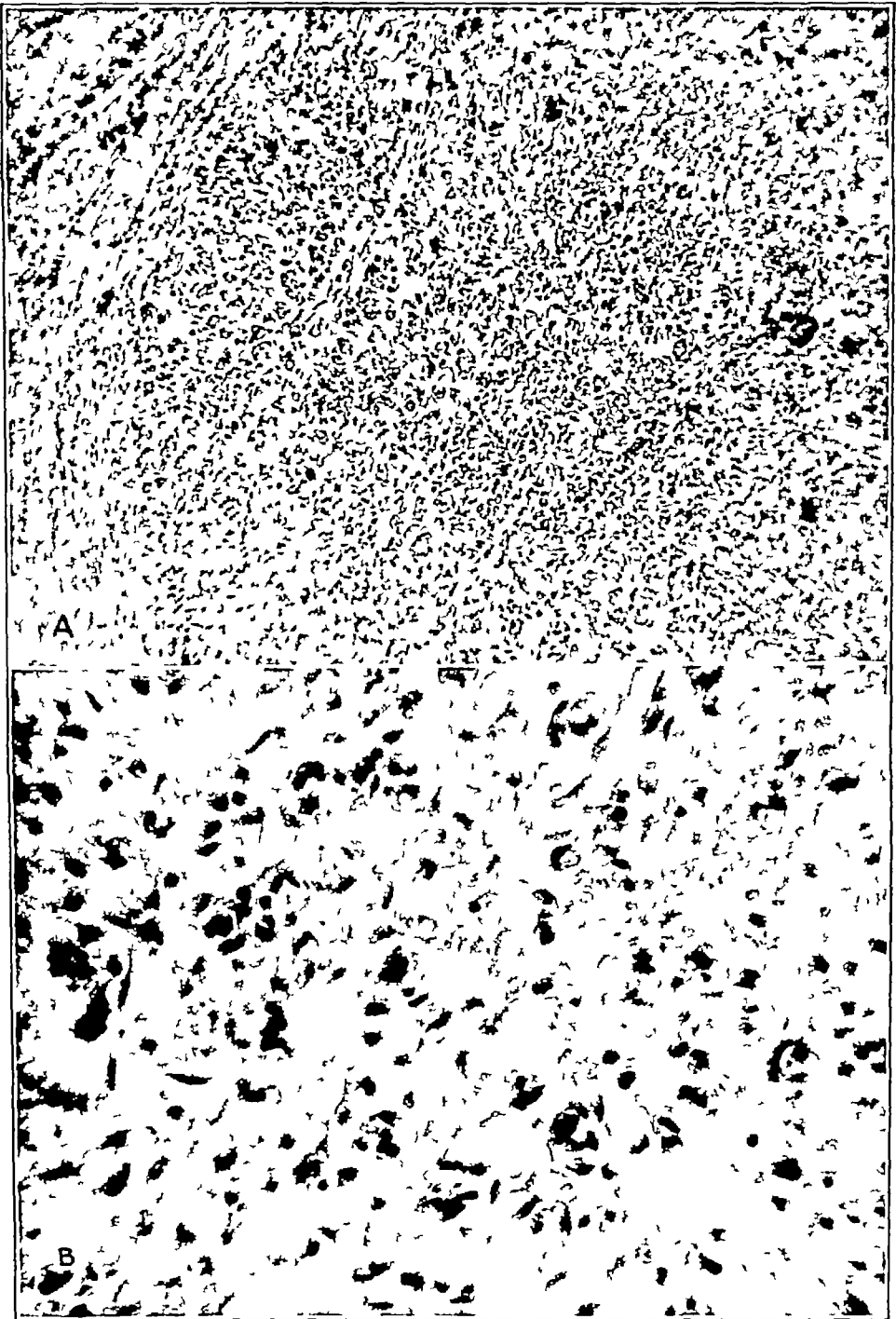


Fig 1—Photomicrographs of radial nerve six weeks after injury, showing axonal destruction and scar formation, with giant cell and fibroblastic activity. Hematoxylin and eosin, *A*, $\times 100$ and *B*, $\times 430$.

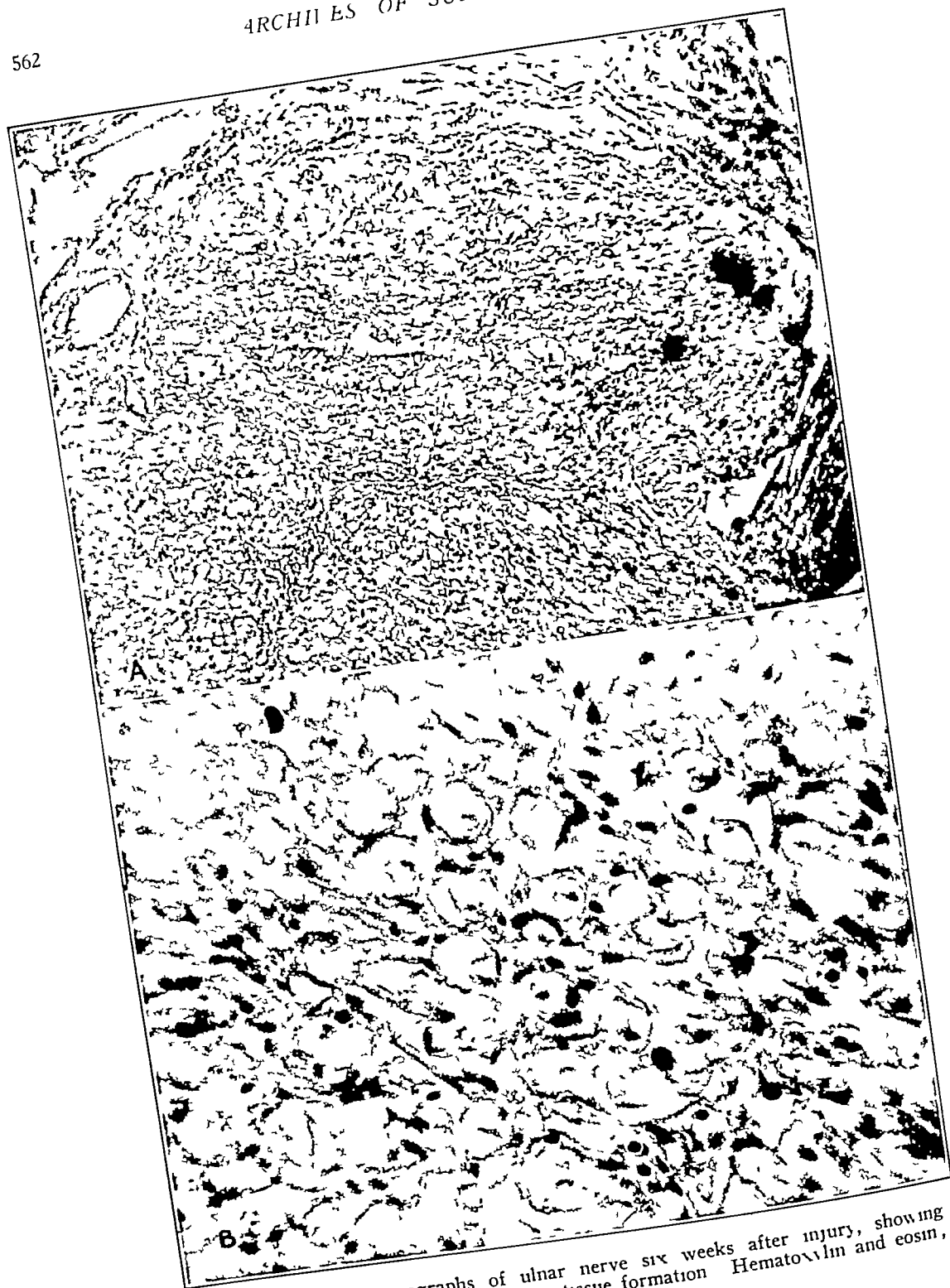


Fig 2—Photomicrographs of ulnar nerve six weeks after injury, showing normal axons and no evidence of scar tissue formation. Hematoxylin and eosin, A, $\times 100$ and B $\times 430$.

Though well defined, glistening, oily, white fasciculi are present, final decision for sufficient resection should depend on the microscopic appearance of the cross section. For this reason, facilities have been made available in the operating room to prepare frozen sections of fresh tissue stained with hematoxylin and eosin.

TECHNIC

There should be no variation from well established surgical principles of wound management. In cases in which the major artery of an extremity has been ligated and extensive soft tissue damage has occurred, thus making circulation dependent on collateral vessels, great care must be exercised to sacrifice as few vessels as possible. In exceptional instances, it is well to precede the nerve exploration by sympathectomy in order to improve circulation. Adequate exposure of the nerve above and below the scarred area is imperative, as it is both time saving and safer to trace the segments into rather than out of the scar.

Gentle manipulation of the nerve trunk and ends is necessary if further damage is to be avoided. Extreme care must be exercised in prevention of tension on the suture line to avoid tearing of the epineurium. Even a small separation of the opposing surfaces may lead to fibroblastic invasion of the open space and formation of a neuroma. Axonal rotation must be avoided if satisfactory functional results are to be obtained. Matching of epineural blood vessels and size or position of fasciculi are helpful in prevention of rotation.

It is never wise to resect remaining conducting fascicles in a wedged injury for a more perfect technical-appearing anastomosis. These few functioning nerve bundles may figure largely in the end result. A so-called lateral or loop-shaped anastomosis ("omega") should be done the normal portion of the nerve being spared.

Direct faradic stimulation of the partial or completely intact nerve is of considerable help in determination of the conductivity through the point of injury. A negative response is unreliable when tested through the intact skin. Frequently the nonconducting nerve as determined through the skin will cause vigorous muscle contraction when applied directly to the nerve. It is needless to say that when there is conduction response of a muscle through a neuroma in continuity that nerve should be subjected only to neurolysis, even though the clinical examination shows complete paralysis.

Various suture materials have been employed and the reactions to tissue studied to discover the one least likely to cause fibrosis. Fine black silk is the commonest material selected, because of its ease of manipulation, slight reaction to tissue and availability. Cotton and hair show increased reaction. Fine tantalum wire is now frequently used.

where available and is believed by some to have even less reaction than black silk. It has some additional advantage of being radio-opaque. Thus, if found separated in a functionless nerve the suture line has obviously been pulled apart. However, it is more difficult to manipulate, more expensive and not always easily obtainable, factors which limit its use. Preparation of the nerve bed is most satisfactory in dry muscle tissue free of scar. Tantalum foil cuffs have recently been used to wrap loosely about the suture site, with the idea of prevention of the ingrowth of fibroblasts. Some months later this material fragments, increases fibrosis and is painful if close to movable joints, necessitating removal. Absorbable fibrin film has been used in the same manner.

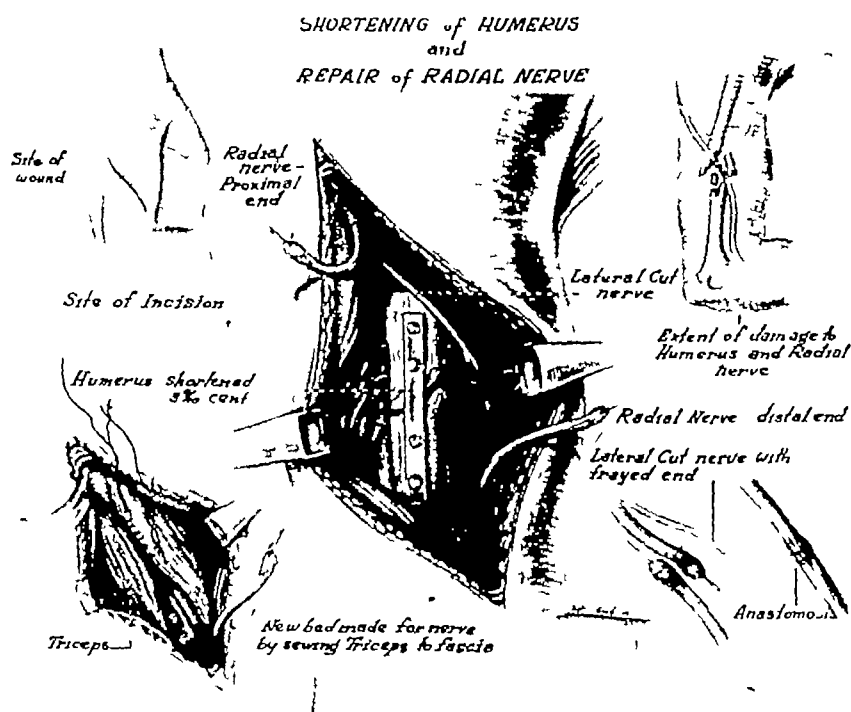


Fig 3—Shortened comminuted fracture of humerus and repair of radial nerve four weeks after injury

but likewise has caused increased fibrosis and has had to be removed. Neither are now recommended by several peripheral nerve centers in the United States.

Length-gaining procedure, such as transplantation of the ulnar to the antecubital space, redirection of the radial to the anteromedial side of the humerus and various degrees of joint flexion, are often necessary to approximate the ends without tension. From 1 to 3 inches (2.54 to 7.62 cm) of the humerus may be removed in a comminuted fracture or resected to gain length in a severed major nerve, with little interference

with the ultimate power of the arm. Figure 3 illustrates shortening of a comminuted fracture of the humerus to gain length for suture of a severed radial nerve. Suture of the median and the ulnar nerve has also been done in a similarly shortened humerus. Resection of the clavicle may be done for length-gaining measures by adduction of the shoulder toward the midline when there are severed components of the brachial plexus. Theoretically there is danger of partially avulsing the proximal segment from the spinal cord during the period of extension if the lesion is high. Later, the date for the beginning of extension of the joint must be decided and the effects of this on the proximal segment, suture line and distal segment considered. Enough down-growing axons should have passed the suture line within three to four weeks to be well into the distal segment, making normal extension safe. From a right angle, it is probably not advisable to extend the extremity fully in less than ten to twelve weeks.

The length to be gained by stretching depends on the elasticity of the nerve, beyond which point damage is done to the axons of the nerve. Most stretching occurs in the segment proximal to a joint because of fixation of the nerve at the operative field by scar. All joints not necessarily immobilized to prevent tension on the suture line should be free for exercise during the period of healing.

NERVE GRAFTS

Grafting has not been undertaken overseas, since it is difficult to obtain autogenous grafts of sufficient size. Homogenous grafts have not been considered worth while. Reports in the United States indicate that little progress has been made in obtaining functioning grafts. A limited number have been reported, all of which have been failures. Lack of success is due chiefly to the fibrosis occurring in the center of the graft and at the distal suture line. This strangles and arrests any axons which have passed the proximal suture line and grown into the graft. It should be noted, however, that grafts reported on were homogenous and were made several months after injury to the nerve. As related in the literature, grafting should be done much sooner if function later is to be possible.

SPLINTING

Prolonged fixation of joints results in frozen extremities, which in itself defeats any motion which might take place from reinnervation of muscle. At first, immobilization appliances should stabilize only the joints necessary to prevent harmful stretching of the sutured nerve. When used for counteracting muscle pull, the appliance should be light weight, elastic, easily removable and of simple design. The patient must be properly instructed concerning exercise of the involved extremity both

in and out of the splint, for the joints must be kept supple during the period of recovery. Radial and peroneal splints are most commonly needed, and several simple types are easily made in overseas installations (figs 4, 5 and 6). These are intended only for temporary use, they

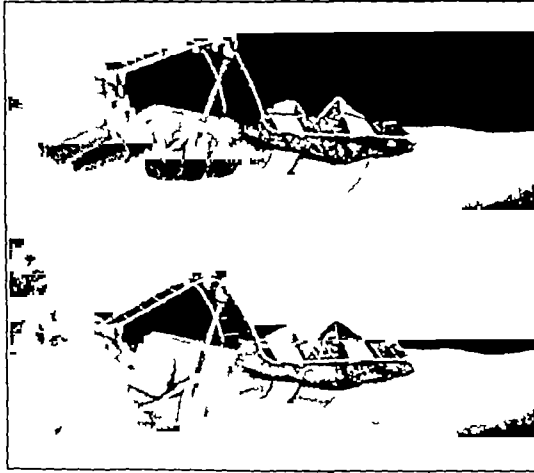


Fig 4—Temporary splint for paralysis of radial nerve hand opened and closed

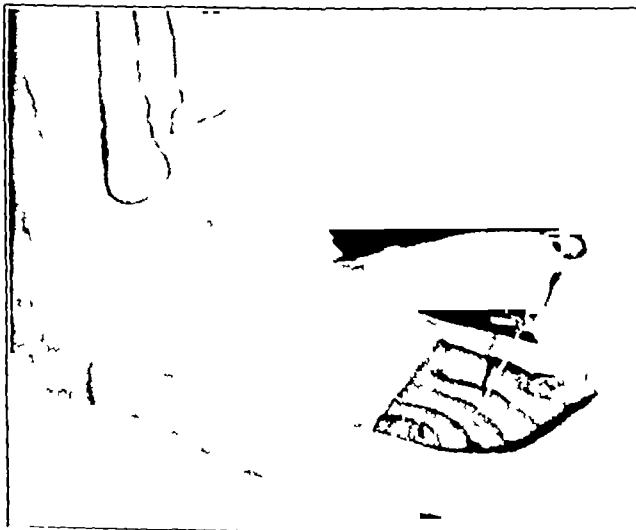


Fig 5—Elastic traction splint on tongue blade beneath toes for paralysis of peroneal nerve.

serve adequately until more refined apparatus can be obtained in the Zone of the Interior. It is not necessary to support the extremity when the ulnar, the median or the tibial nerve is paralyzed.

CAUSALGIA

Traumatic neuritis terminating in severe causalgia occurs infrequently but when present causes profound mental and physical reactions of the patient. This pain occurs most frequently in an incompletely severed median or sciatic nerve. Suture of the partially severed nerve often causes permanent relief of pain. When direct attack on the injured nerve is unsuccessful or inadvisable, further procedures should be undertaken without delay, since continued paresthetic discomfort is quickly fixed on the thalamic centers. Interruption of the sympathetic



Fig 6—Peroneal brace incorporated in shoe, with rubber tubing maintaining elastic support to foot

nerve supply to the part by procaine hydrochloride or surgical division gives the best results. In delayed causalgic states, only cortical extirpation of the sensory centers may afford relief. Twenty-two patients with causalgia were treated by us. There were twelve injuries of the sciatic nerve, four of the peroneal nerve, four of the median nerve, two of the tibial nerve and one of the brachial plexus. Three patients were relieved by injection of procaine hydrochloride into a sympathetic nerve and 5 by neurolysis, and 2 had relief after suture of the partially divided sciatic nerve. One patient with causalgia of the median

nerve and 1 with causalgia of the bronchial plexus were relieved after thoracic sympathectomy. Ten were discharged without operative treatment.

DISCUSSION OF CASES

Several factors have limited the number of patients who have been operated on under the present plan. The rapid turnover of patients at an evacuation hospital prevents the holding of them for sufficient time for postoperative observation during periods of combat activity. Cases of craniospinal lesions of necessity take precedence over cases of injury to the peripheral nerve. High plane priority to the Zone of the Interior also favors evacuation rather than holding of the patient for definitive surgical treatment.

One of us (D. H. W.), working in an evacuation hospital, observed one hundred and forty-three traumatized nerves at the time of initial

TABLE 1—*Incidence of Nerve Injury*

Nerve	Number of Cases
Ulnar	65
Radial	22
Median	30
Brachial plexus	3
Peroneal	19
Sciatic	19
Tibial	6
Medial femoral cutaneous	3
Musculocutaneous	7
Femoral	2
Axillary	2
Total	179

wound debridement. Sixty-four per cent of these were either completely or partially severed, while 36 per cent showed various degrees of damage in continuity. Fifty-two nerves were repaired at the time of primary debridement. No infection occurred to interfere with the suture line while the patients were under observation. While adequate follow-up studies have not been possible, 12 patients have been heard from during a period of one year, and all had shown some evidence of recovery.

Two of us (J. L. T. and W. P. R.) have operated on 179 patients with nerve injuries in general hospitals. Table 1 shows the distribution of the involved nerves.

In this group there were 70 cases of severed nerves and 109 cases in which only neurolysis was required. Twelve neuromas in continuity were resected and the nerve resutured. These were included in the group of cases of severed nerves.

The large number of neurolyses done clearly shows the need for accurate observation and description of the injured nerve at the time

of debridement. The average preoperative interval for this group of cases was forty-two days. Only one severe infection occurred, this probably resulted in destruction of the suture line. One other superficial infection healed promptly under penicillin therapy. Chemotherapy was not used routinely in these cases.

A follow-up study has been started by one of us (L. A. F.) on a group of 410 patients with nerve lesions. Replies have been received from 219, or 53 per cent, of these patients. This includes the patients in operative cases (thirty-nine primary sutures and seventy-three neurolyses) as well as the patients not operated on but discharged to the Zone of the Interior or overseas duty because of the nerve palsy.

Table 2 shows the data on recovery following nerve suture in relation to the preoperative interval. Eighteen neurorrhaphies were

TABLE 2—*Recovery Following Suture*

Preoperative Interval, Wk	Total Cases	Follow Up	Beginning Return Function Average Time, Mo	Recovery Still Progressing, Average Time, Mo	Recovering	No Recovery
Under 8	18	10	6	16	7	3
3 to 6	8	0	6	14	4	1
6 to 12	11	8	5	18	4	4
Over 12	2	1			0	1
	39	24	5.7		15	9

performed within the first three weeks. There were no infections in this group. The first sign of returning function appeared on an average in six months and was still increasing after sixteen months. Three patients had no return after one year or more. Eight sutures were performed in the three to six week interval. Here too the first signs of recovery were noted in six months, and function was still returning on an average after fourteen months. There was no return in 1 patient. Eleven neurorrhaphies were done in the six to twelve week interval. Here, again, the average period before recovery began was five months, and function was still returning on an average of eighteen months later. Four patients showed no return of function. Two sutures were performed after three months, follow-up revealed no return of function in 1 patient, and we have heard indirectly that there was no return in the other.

The most interesting feature in this group is the fact that as the preoperative interval increased the average time until the first signs of recovery or until return was well under way remained unchanged but there was a definite increase in the number that showed no signs of return. It took six months on an average before the first signs of

recovery were noted. In many patients it could not be accurately determined whether or not they were misinterpreting sensory overlap with true return of protopathic sensation. Therefore motor recovery was often the criterion.

Table 3 shows the average number of days required for some return of function in patients on whom neurolyses were performed. The shorter the preoperative interval, the earlier recovery began and the sooner it became complete or nearly so. It is possible that some of the patients might have recovered spontaneously. The average period for beginning recovery was thirty and one-half days and for partial or complete recovery was six months. It was noted that sciatic and peroneal nerves did not show recovery as soon as others.

The data in table 3 indicate that in the neurolyses the percentage of recovery was also influenced by the preoperative interval. In patients

TABLE 3—*Recovery Following Neurolysis*

Preoperative Interval, Wk.	Total Cases	Follow Up	Beginning Return, Average Time Days	Partial to Complete Recovery, Average Time, Mo.	Recovered	No Recovery
Under 3	21	12	22	4	11	1
3 to 6	24	18	32	6	16	2
6 to 12	13	14	28	7	10	4
Over 12	16	8	40	7	4	4
	78	52	30.5	6	41	11

in whom over three months had elapsed prior to neurolysis, the chance of recovery was definitely decreased. Apparently some permanent damage must have taken place.

SUMMARY AND CONCLUSIONS

Formal nerve suture may be done without fear of infection within five weeks following injury when the soft tissue wound has been closed and has healed promptly. Primary suture is safe at the time of debridement in the uncomplicated wound. The conditions under which the procedure is feasible have been described. The greater number lend themselves to repair four to six weeks after successful secondary closure of the wound. A limited follow-up study shows that the early repaired severed nerves tend to recover earlier and more completely than those repaired after three months.

The most important advance in the field of peripheral nerve surgical treatment in this war is early suture of the severed nerve.

MORPHOLOGY AND VARIATIONS OF THE DUODENAL VASCULATURE

Relationship to the Problems of Leakage from a Postgastrectomy
Duodenal Stump, Bleeding Peptic Ulcer and Injury to the
Common Duct

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AND
GREGORY L. ROBILLARD, M.D.
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DESPITE its increasing clinical importance, the blood supply of the duodenum has as yet been accorded little emphasis by anatomists. With a few exceptions, the meager and partially inaccurate descriptions in standard surgical and anatomic texts still reflect the teachings of a period when detailed consideration of the duodenal vasculature was pointedly dismissed as unwarranted because of its presumed surgical inaccessibility.¹ Accurate knowledge of the arterial distribution of the duodenum, however, has become significant in the light of the relatively recent development of gastroduodenal, common duct and pancreatic surgical procedures. Of the several studies published since the turn of the century, almost all have been essentially concerned with the problem of massive hemorrhage in duodenal ulcer. The present investigation was initially undertaken to determine primarily the possible contributory role of devascularization incident to the usual surgical mobilization of the duodenum in dehiscence of the postgastrectomy stump but was later expanded to a more general survey of the duodenal circulation.

THE PROBLEM OF POSTGASTRECTOMY DUODENAL LEAKAGE

As expressed by the majority of writers on the subject² the major technical difficulty encountered in the procedure of subtotal gastrectomy

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1 Callander, C. L. *Surgical Anatomy*, ed 2, Philadelphia, W. B. Saunders Company, 1942.

2 (a) Bancroft, F. W. *Operative Surgery*, New York, D. Appleton-Century Company, Inc., 1940. (b) Clute, H. M. Duodenal Stump Closure in Gastric Resections, *New England J. Med.* **214**: 724, 1940. (c) Lahey, F. H. Technical Difficulties with Gastric Resection, *S. Clin. North America* **17**: 693, 1937. (d)

(Footnote continued on next page)

is the securing of a leakproof closure of the duodenal stump. The reported mortality of gastric resection varies roughly from 2 to 30 per cent,³ with postoperative duodenal fistula and resultant peritonitis reported in most series of cases as the major cause of death.⁴ As stated later in this paper, most recent standard texts on operative surgery as well as a great number of current articles recommend mobilization of several centimeters of duodenum during subtotal gastrectomy as a requisite for satisfactory closure of the stump. In several scores of descriptions of operative technic, no warning statement was encountered concerning the possible dangers of devascularization of the stump in the carrying out of the prescribed separation of the segment to be inverted from the head of the pancreas.

Review of the literature on the cause of postoperative duodenal fistula elicited numerous other explanations without reference to the possibility that ischemic necrosis might be a causative factor. A usual assumption is that the digestive action on surgical gut suture material and traumatized tissues of the relatively undiluted secretions poured out by the pancreatic and common bile ducts is in large measure responsible for most instances.⁵ Proponents of clamp methods insist that the crushing of the duodenal wall facilitates adequate closure.^{2b} Advocates of open methods of stump sealing after duodenal division are critical of clamp procedures as productive of devitalization and hence predisponent to postgastrectomy leakage.^{2c} Appraisal of end results, however, fails to reveal any statistically significant difference between the two technics so far as the incidence of so-called duodenal blow-out is concerned. Steinberg⁶ cited several possible causes of leakage from the stump of the duodenum as follows: poorly healing inflammatory tissue of the ulcer bed included in the suture line, faulty closure, i. e., failure sufficiently to mobilize the anterior wall, devitalization of tissue by crushing clamps, action of pancreatic juice escaping from an injured

McNealy, R. W. Problems with Duodenal Stump in Gastric Resections, *Surgery* **12** 207, 1942. (e) Slive, A., Shock, D., and Fogelson, S. J. An Experimental Study of Methods for Closing the Duodenal Stump After Gastric Resection, *ibid* **13** 741, 1943.

3 (a) Lake, N. C. Partial Gastrectomy, *Brit. M. J.* **2** 49, 1937. (b) Still, R. J. Mortality and Later Results of Subtotal Gastrectomy, *Lancet* **2** 1030, 1936.

4 (a) Berg, A. A. Mortality and Late Results of Subtotal Gastrectomy, *Ann. Surg.* **92** 340, 1930. (b) Clute.^{2b} (c) Colp, R., and others. Subtotal Gastrectomy for Duodenal Ulcer, *Ann. Surg.* **120** 170, 1944. (d) Footnote 3. (e) St. John, F. B., and others. A Study of the Results of Surgical Treatment of Peptic Ulcer, *Ann. Surg.* **109** 193, 1939.

5 Horsley, J. S., and Bigger, I. A. *Operative Surgery*. St. Louis, C. V. Mosby Company, 1940.

6 Steinberg, M. E. Surgical Treatment of Gastroduodenal Ulcerations, *Surg., Gynec. & Obst.* **71** 317, 1940.

pancreatic lobule or the base of the ulcer, ligation of the major arteries, namely, the gastroduodenal, pancreaticoduodenal or right gastroepiploic, at their points of origin, and ligation of a functioning accessory pancreatic duct which blows out with sufficiently accumulated intraductal pressure. It is noteworthy that in his discussion of leakage from the gastrojejunal anastomosis, however, the first point mentioned is tissue necrosis⁶ due to poor blood supply. For some reason, the necessity for painstaking precautions to preserve the mesenteric blood supply of the jejunoleum and colon has been stressed by surgeons,⁷ without overt recognition being granted the fact that similar safeguards are as essential in an operation on the duodenum. The concept of the safety factor in ligations of the arterial supply of the intestinal wall should obviously be as applicable to this area as to others. However, the knowledge, confirmed experimentally by Bernheim,⁸ that the wall of the stomach, unlike that of the intestine proper, survives major arterial ligations relatively well because of a rich arterial intramuscular rete seems to have obscured the fact that immediately past the pylorus one is dealing with alimentary wall that tolerates ligature ischemia probably even less well than does jejunoleum. More extensive consideration of this matter will be given later.

Horsley⁵ suggested that an increase in duodenal back pressure followed the Billroth II-type of operation. McNealy^{2d} amplified this idea by illustrating how angulation of the jejunal loop immediately proximal to the gastrojejunal anastomotic stoma would lead to closed loop obstruction of the blind duodenal limb and a resultant blow-out. Raffel⁹ proposed a means of overcoming this, accepting the same causative mechanism, by intubation of the duodenal loop and the jejunum simultaneously as a postoperative measure, using a modified bifurcated Levine tube attached to a suction drainage apparatus. Slive and colleagues^{2e} concurred that increased intraluminal pressure is operative in the causation of dehiscence of the duodenal stump. None of the foregoing workers, however, made mention of the possibility that apical ischemic necrosis of the blind loop might lead to leakage through local digestant action by the duodenal contents, with minimal or no elevation of intraduodenal pressure. Leakage at the gastroduodenal anastomosis, much commoner than that from gastrojejunal stomas, was according to Horsley⁵ the reason for the abandonment of the Billroth I procedure,

7 Aird, I. Morbid Influences in Intestinal Obstruction and Strangulation, *Ann Surg* **121** 74, 1945. Oppenheimer, M. J., and Mann, F. C. Intestinal Capillary Circulation During Distention Surgery, **13** 548, 1943.

8 Bernheim, B. M. Partial and Total Devascularization of the Stomach, *Ann Surg* **96** 179, 1932.

9 Raffel, W. New Method for Physiologic Decompression After Gastric Operations, *Arch Surg* **42** 1083 (June) 1941.

and in these circumstances too, without increased back pressure, ischemic necrosis might have been the cause

The currently most favored procedure for closure of the duodenal stump is the Kerr-Parker method or a modification²⁰ Essentially, the cut edge of the duodenum has been crushed with a clamp, over which a continuous Cushing seromuscular suture inverts the edges, whereupon the clamp is withdrawn and the suture pulled taut This is followed by a second and possibly a third reinforcing row of seromuscular sutures Wangenstein¹⁰ advocated the sealing of the duodenum initially with a von Petz clamp, while Clute¹¹ utilized a modified Furness clamp for closure Doyen¹² placed a ligature about the site of the clamp and inverted the stump with purse string sutures Von Haberer¹³ practiced open section of the duodenum without clamps, closing with a continuous Connell suture and a second row of continuous seromuscular sutures Most surgeons recommend fine chromic surgical gut for the first row, using silk for the final row of sutures¹⁴ Review of the recent literature reveals that Maingot,¹⁵ Orr,¹⁶ Cutler and Zollinger,¹⁷ Marshall,¹⁸ Elason and Stevens,¹⁹ Fallis,²⁰ Thorek,²¹ Horsley,⁵ Callander,¹ Monteiro,²² Garacotche²³ Lahey,²⁴ Spivack,²⁵ Graham,²⁶ Pack and Livingston,²⁷

10 Wangenstein, O Problem of Surgical Arrest of Massive Hemorrhage in Duodenal Ulcer, *Surgery* **8** 275, 1940

11 Clute, H M Total Gastrectomy for Cancer of the Stomach, in Pack, G T, and Livingston, E M Treatment of Cancer and Allied Diseases, New York, Paul B Hoeber Inc, 1940, chap 59

12 Doyen, E Traitement chirurgical des affections de l'estomac et du duodenum, ed 9, Paris Rueff & Cie, 1895

13 von Haberer, H Zur Frage des Ulcus pepticum jejuni auf Grund alterer und neuerer klinischer Erfahrungen, *Arch f klin Chir* **119** 712, 1922

14 Lindner, H H, and Moore, J M Silk Its Effect and Fate in Intestinal Anastomoses, *Surgery* **10** 684, 1941

15 Maingot, R Abdominal Operations, New York, D Appleton-Century Company, Inc, 1940

16 Orr, T G Operations of General Surgery, Philadelphia, W B Saunders Company, 1944

17 Cutler, E C, and Zollinger, R Atlas of Surgical Operations, New York, The Macmillan Company, 1939

18 Marshall, S F Surgical Management of Chronic Peptic Ulcer, *S Clin North America* **24** 618, 1944

19 Elason, E L, and Stevens, L W Surgical Aspects of Peptic Ulcer, *S Clin North America* **24** 1282, 1944

20 Fallis, L S Technic of Gastric Resection for Carcinoma, *S Clin North America* **23** 1259, 1943

21 Thorek, M Modern Surgical Technic, Philadelphia, J B Lippincott Company, 1938

22 Monteiro, A, and others Aseptic Gastrectomy, *Rev brasil de cir* **12** 775, 1943

Clute,^{2b} Wangenstein,¹⁰ Steinberg,⁶ Ogilvie²⁸ and Partipilo²⁹ among others have illustrated various clamp technics of closure Colp,^{4c} Berg³⁰ Nissen,³¹ Rienhoff³² and Kirschner³³ are among those who have advocated nonclamp methods Irrespective of the closing procedure adopted, dehiscence of the duodenal stump and fistula are cited as the greatest postoperative hazards and mortality factors by Clute,^{2b} Steinberg,⁶ McKittrick and colleagues,³² Walters,³⁴ Devine,³⁵ Horsley,⁵ Colp,^{4c} Still,^{3b} Monteiro,²² McClure and Fallis,³⁶ St John and colleagues,⁴⁰ Nissen,³¹ Graham,²⁶ Berg^{4a} and McNealy^{2d} Mortality rates after gastric resection vary from roughly 2 to 30 per cent^{3a} Lake^{3a} estimated the average death rate at 10 per cent and gave it as his opinion that the pronounced variation in reported mortalities of several decades ago in several series of cases each exceeding 100 probably represented sampling differences in selection of cases Thus Moynihan's mortality rates of 1.9 per cent, over thirty years ago, differed considerably from Finsterer's of 18 per cent, and Balfour's of 5.2 per cent, whereas all three men were eminent and contemporary surgeons^{3a} Such more recently reported mortality rates as those of Berg³⁰ (6.9 per cent), McKittrick and colleagues³² (8.1 per cent), Walters³⁴ (1.9 per cent) and McClure³⁶

23 Garacotche, I Review of Techniques for Subtotal Gastrectomy, *Semana med* **49** 166, 1942

24 Lahey, F H, and others *Surgical Practice of the Lahey Clinic*, Philadelphia, W B Saunders Company, 1942

25 Spivack, J *Surgical Technic of Abdominal Operations*, Chicago, S B Debour, 1942

26 Graham, R R *Technic of Gastric Resection for Duodenal Ulcer*, S Clin North America **23** 1394, 1943

27 Pack, G T, and Livingston, E M *Treatment of Cancer and Allied Diseases*, New York, Paul B Hoeber, Inc, 1940, chap 60

28 Ogilvie, W H Some Points in the Operation of Gastrectomy, *Brit M J* **1** 457, 1935

29 Partipilo, A V *Surgical Technique*, Chicago, John Maher Publishing Company, 1938

30 Berg, A A Partial Gastrectomy for Cancer of the Stomach, in Pack, G T, and Livingston, E M *Treatment of Cancer and Allied Diseases*, New York, Paul B Hoeber, Inc, 1940, chap 58

31 Nissen, R *Duodenal and Jejunal Peptic Ulcer*, New York, Grune & Stratton, Inc, 1945

32 McKittrick, L S, Moore, F D, and Warren, R Complications and Mortality in Subtotal Gastrectomy for Duodenal Ulcer, *Ann Surg* **120** 531 1944

33 Kirschner, M *Operative Surgery*, Philadelphia, J B Lippincott Company, 1933

34 Walters W, and others Primary Partial Gastrectomy for Duodenal Ulcer, *Surg, Gynec. & Obst* **71** 240, 1940

35 Devine, H *Surgery of the Alimentary Tract*, Bristol, John Wright & Sons, Ltd, 1940

36 McClure R D and Fallis, L S Partial Gastrectomy for Peptic Ulcer, *Surgery* **8** 575, 1940

(54 per cent) suggest some reduction in over-all mortality but with a persistent great variation while comparable procedures are utilized, presumably still indicative of basic sampling differences. St John⁴⁶ estimated that of operative deaths 37.5 per cent to 68.8 per cent are attributable to leakage at the suture line, predominantly of the duodenal stump. About 50 per cent of the deaths in McClure's³⁶ series, 30 per cent in Hunt's,³⁷ 30 per cent in McKittrick's,³² 20 per cent in Lake's,^{3a} 25 per cent in Colp's^{4c} and 25 per cent in Walters'³⁴ were due to peritonitis secondary to duodenal fistula. Of approximately 100 cases in which prophylactic operative drainage of the closed stump was instituted, Colp^{4c} reported that biliary discharge occurred in 16. If Lake's estimate^{3a} of the average mortality in subtotal gastrectomy as 10 per cent is correct and 30 per cent is considered the fraction of deaths due to duodenal leakage, then in some 3 per cent of persons subjected to the usual technic of subtotal gastrectomy this fatal complication is to be expected. Colp^{4c} and others interpreted the frequently encountered postoperative signs of localized peritonitis of the right upper quadrant, with recovery, as likewise due predominantly to insecure closure of the duodenal stump, and present figures, notably those quoted on biliary drainage from the stump site, that might be construed as an indication of some fault in closure in at least 15 per cent of patients. A possible significance of these figures in relation to the anatomic configuration of the duodenal arteries and the safety factor in ligations of duodenal vasa recta will be discussed subsequently.

Experimental studies using dogs to determine optimum methods for closure have been carried out by Perelman³⁸ and Slive, Shock and Fogelson.³⁹ The former concluded that the Kerr-Parker clamp method gave the best results. The latter workers found, on the other hand, that the open method of von-Haberer, using a silk or surgical gut ligature followed by a silk purse string suture, was most satisfactory. Their main criterion was the fact that between the fifth and eighth postoperative days, the period of greatest postoperative mortality, the duodenal stump showed measurably greater resistance to an induced increase in intraluminal pressure. Neither study commented on the possibility of stump devascularization as a factor, nor is any statement made as to the significance of the difference in duodenal circulation between the dog and man, a matter to be elaborated on later. The latter authors conceded that anatomic and pathologic considerations may frequently warrant the choice of the clamp over the open method.

37 Hunt, C. J. Radical Resection of Stomach in Cancer, *South M. J.* **33** 234, 1940.

38 Perelman, G. V. Comparative Value of Various Methods of Treating the Duodenal Stump After Gastric Resection, *Novy khir. arkhiv* **39** 270, 1937.

PREVALENT TECHNICS OF DUODENAL MOBILIZATION
PRIOR TO CLOSURE

Duodenal mobilization by an incision of the peritoneum lateral to the organ and reflection of it medially in the fashion recommended by Finsterer³⁹ and used for the Finney⁴⁰ pyloroplasty is routinely carried out by a number of surgeons in the performance of subtotal gastrectomy of the usual or the Mayo-Polya-Billroth II type, although there appears to be some controversy as to its practicability and safety. Thus Thorek²¹, Devine³⁵, Horsley,⁵ Steinberg⁶ and Mangot¹⁵ practiced this step, while Nissen³¹ held that in so doing many retroduodenal vascular adhesions have to be divided, thereby endangering the blood supply of the posterior wall as well as that of the common duct proper. It should be noted, however, that this concept that the posterior duodenal wall is dependent on retroperitoneal bands for its circulation appears to receive no confirmation elsewhere.

Almost universally prescribed, however, is the separation of the duodenum for a varying distance of its first and the uppermost portion of its second part from the head of the pancreas. This maneuver is what is generally meant by "mobilization" of the duodenum in the process of gastrectomy. A fairly common recommendation is for the freeing of at least 2 or 3 cm. below the applied clamp to facilitate inversion. In the usual accompanying illustrations, often accepted as a guide, and in practice at least 3 or 4 cm. or more are more often than not so liberated. Our dissections indicate that the stripping of the duodenum in this wise effectively devascularizes it as a rule by the severing of several consecutive vasa recta and that unless serosal inversion is carried out somewhat beyond the point where the duodenum still remains attached to the pancreas and hence with its local circulation intact the apical plug of inverted tissue is liable to ischemic necrosis. Consequently the directions for the freeing of this duodenal segment, as given by several writers, will be reviewed in some detail.

Thorek²¹ stated simply that it may be necessary to shave off the pancreas and pictured what appears to be at least 3 cm. of separated stump, judged from the ratio of duodenal cross section to length of the stump. Horsley's⁵ instructions are to free the duodenum from the pancreas by cautery leaving likewise several centimeters of freed stump. Colp⁴⁰ stressed preliminary freeing of "adequate" duodenum from pancreas. Monteiro⁴² utilizing a triple clamp method in an attempt to make more certain of duodenal sealing appears to mobilize more than 3 cm. of duodenum. Garacotche²³ illustrated section and ligation of the

39 Finsterer H. Surgical Treatment of Acute Profuse Gastric Hemorrhages. Surg. Gynec. & Obst. 69: 291, 1939.

40 Finney J. M. T. and Hanrahan E. M. Jr. Gastric Ulcer. In Lewis D. Practice of Surgery, Hagerstown, Md. W. F. Prior Company, 1944, vol. 6, chap. 6.

arterial rami duodenales of the entire upper third of the descending duodenum Nissen,³¹ after advising against mobilization of the posterior wall, stated that "very complete mobilization of the anterior wall is essential," since "tension of sutures may bring on duodenal leakage. Before incising into gut proper to expose the ulcer crater, both forefingers are used for blunt separation of the anterior wall of the duodenum from overlying adhesions and the head of the pancreas, being careful that pancreatic tissue should not be damaged in ligating vessels adjacent to the lower border of the duodenum." Graham²⁹ divided the peritoneal reflection on the concave and convex aspects of the second part of the duodenum, ligated the superior pancreaticoduodenal artery as well to permit dissection of the posterior wall below the first part of the duodenum and utilized a three clamp technic requiring at least 3 cm of freed stump. Clute,⁴¹ before application of the Furniss clamp, required that "the pylorus and duodenum be separated from the pancreas and fully mobilized." Pack and Livingston²⁷ illustrated several methods of closure, all showing roughly 3 to 4 cm of freed stump, and advised that the operator "insinuate his fingers behind the duodenum and gently separate this structure from the pancreas by blunt dissection." The nutrition of the stump is still insured, in their opinion, by anastomoses with the inferior pancreaticoduodenal artery, should the superior vessel be ligated. Berg⁴² counseled separation of the duodenum from the pancreas and pointed out that during this separation several branches of the pancreaticoduodenal artery are usually divided and that they must be carefully clamped and ligated, since a "hematoma may lead to duodenal fistula." Wangensteen's¹⁰ illustrations reveal the freeing of apparently 3 to 4 cm of duodenum from the pancreas, with ligatures on three anterior and three posterior rami duodenales. Lahey²⁴ required about an inch (2.5 cm) of duodenum so as not to invert under tension after division between Ochsner clamps. Maingot¹⁸ said that the pylorus and the first portion of the duodenum are mobilized by underrunning the numerous vascular bands and adhesions on the superior, inferior and posterior aspects of the bowel. Kirschner³³ and Partipilo²⁹ dissected the duodenum from the pancreas to a level where they warned against cutting the pancreatic ducts. Finney⁴⁰ illustrated ligation and separation of approximately 5 cm of the medial border of the duodenum. Steinberg⁶ diagrammed the freeing of the lateral and medial borders of the upper area of the second part of the duodenum and, apparently overlooking the fact that they are vasa recta, made the statement that "numerous delicate arteries and veins are present which

41 Clute (footnotes 2 b and 11)

42 Berg (footnotes 4 a and 30)

prove a troublesome source of hemorrhage" Ogilvie,²⁸ with similar explicit disregard for the terminal arterioles to this segment of bowel, said that of the "abundant supply of vessels the most troublesome are the group entering it from the pancreas, which must be secured by a number of small ligatures before enough of the wall is mobilized to allow for safe occlusion or anastomosis"

One must note again, therefore, that in no descriptions of technic for gastrectomy is the reader cautioned against the freeing of too generous a length of duodenum prior to inversion lest its blood supply be endangered. Rather, the operator is encouraged to dissect liberally to facilitate the mechanics of handling the stump in inversion. Almost all writers advocate the burying of the inverted stump against pancreas, a stratagem that literally requires that the segment be mobile enough to do so. Although it may be the actual practice of individual surgeons of experience to guard against devascularization, published teachings would not so indicate. Only two casual unpublicized references to this matter, neither in an article on subtotal gastrectomy proper, could be unearthed by us after diligent search. Wilkie,⁴³ referring not to vasa recta but to the meagerness of arterial supply in the first part of the duodenum receiving the supraduodenal artery, an area as a rule entirely excised in subtotal gastrectomies, made this observation: "The liability of one or more of its leading vessels of supply to the ligatured [a reference to major arteries rather than terminal branches] explains the danger of leakage from the duodenal stump after the operation [of pylorotomy]." Reinhoff, in the discussion following McKittrick's paper,³² came to the guarded conclusion that "sometimes the circulation of the stump may be slightly jeopardized due to separation of the intestine from the head of the pancreas." Mobilization of the duodenum too far down the second portion is thought to be inadvisable, because of possible injury to the common duct or interference with the circulation of the duodenal stump. Although no specific reference is made to the configuration and role of the duodenal vasa recta, this suggestion, appearing while the present work was in progress, was the only discoverable published mention of the need for concern over the intrinsic circulation of the duodenal stump in gastrectomy. To recapitulate, the diverse technics already presented all calculated to obviate the tremendous hazard of leakage of the duodenal stump by freeing of the duodenum from the head of the pancreas to simplify inversion would in so doing, in the light of our anatomic findings at the same time appear to devascularize the stump and tend in that manner to defeat their own purpose.

43 Wilkie D P D The Blood Supply of the Duodenum with Special Reference to the Supraduodenal Artery, Surg Gynec & Obst 13 399 1911

THE ANATOMY OF THE DUODENAL BLOOD VASCULATURE

Although studies on gastrectomy and pancreaticoduodenectomy have appeared with increasing frequency in the surgical literature of the last fifteen years, systematic review of recent standard American and British textbooks of anatomy disclosed only partially correct and cursory descriptions by all but two of some twenty authorities. In Gray's,⁴⁴ Piersol's,⁴⁵ Morris',⁴⁶ Rouviere's,⁴⁷ Quain's⁴⁸ and Mainland's⁴⁹ texts, only a single major or anterior pancreaticoduodenal arterial arch is mentioned. Similarly, the Sobotta,⁵⁰ Spalteholz,⁵¹ Jamieson,⁵² Warren⁵³ and Toldt⁵⁴ atlases illustrate but one arcade. Among references in surgical anatomy, Callander¹ described only one arterial anastomotic circle running in the pancreaticoduodenal groove and dismissed it perfunctorily as "rarely coming into surgical importance." McGregor,⁵⁵ Deaver,⁵⁶ Massie⁵⁷ and Treves⁵⁸ devoted only several short sentences to the entire intestinal circulation. Among dissector's handbooks, those of Shearer,⁵⁹

44 Gray, H. *Anatomy of the Human Body*, edited by W. H. Lewis, ed 24, Philadelphia, Lea & Febiger, 1942.

45 Piersol, G. A. *Human Anatomy*, ed 9, Philadelphia, J. B. Lippincott Company, 1930.

46 Morris, H. *Morris' Human Anatomy*, ed 10, Philadelphia, The Blakiston Company, 1942.

47 Rouviere, H. *Anatomie humaine*, Paris, Masson & Cie, 1924.

48 Quain, J. *Elements of Anatomy*, London, Longmans, Green & Co., 1914.

49 Mainland, D. *Anatomy as a Basis for Medical and Dental Practice*, New York, Paul B. Hoeber, Inc., 1945.

50 Sobotta, J. *Atlas of Human Anatomy*, edited by J. P. McMurrich, ed 2, New York, G. E. Stechert and Company, 1928.

51 Spalteholz, W. *Hand Atlas of Human Anatomy*, ed 7, Philadelphia, J. B. Lippincott Company, 1937.

52 Jamieson, E. C. *Illustrations of Regional Anatomy*, Baltimore, Williams & Wilkins Company, 1942.

53 Warren, J. *Handbook of Anatomy*, Cambridge, Mass., Harvard University Press, 1942.

54 Toldt, C. *Atlas of Human Anatomy for Students and Physicians*, ed 2, New York, The Macmillan Company, 1944.

55 McGregor, A. L. *Synopsis of Surgical Anatomy*, ed 5, Baltimore, Williams & Wilkins Company, 1943.

56 Deaver, J. B. *Surgical Anatomy of the Human Body*, ed 2, Philadelphia, P. Blakiston's Son & Co., 1926.

57 Massie, A. *Surgical Anatomy*, ed 3, Philadelphia, Lea & Febiger, 1937.

58 Treves, F. *Surgical Applied Anatomy*, ed 8, Philadelphia, Lea & Febiger, 1926.

59 Shearer, E. M. *Manual of Human Dissection*, Philadelphia, P. Blakiston's Son & Co., 1937.

Heisler⁶⁰ and Jamieson⁶¹ likewise depicted but one major anastomosis. Only the Cunningham textbook⁶² and practical manual⁶³ and the Grant text⁶⁴ and atlas⁶⁵ describe the duodenal circulation in any detail and in relative accordance with the findings in this and other fairly recent reports⁶⁶. Moreover, during the past twenty years only one comprehensive study⁶⁷ of the blood supply of the duodenum, with findings somewhat at variance with our own, has appeared in journals in the English language, although several investigations primarily devoted to the pancreatic circulation have been published. The following survey of the duodenal circulation is drawn from descriptions in accordance with our own studies from the several sources quoted as well as from our own observations.

Dissections were made of 62 bodies, although percentages quoted here from our own specimens are generally from a somewhat smaller number, since in some dissections only one region under investigation was thoroughly worked out. All the bodies were refrigerated, they were those of persons who had died less than two days before, and the anatomic studies were made in the course of complete necropsy. No bodies were included in which pathologic changes or extreme obesity existed of such a nature as to obscure the structure of the celiac and superior mesenteric trunks or branches. No arterial color mass injec-

60 Heisler, J. C. *Practical Anatomy*, Philadelphia, J. B. Lippincott Company, 1912.

61 Jamieson, E. C. *Companion to Manuals of Practical Anatomy*, ed. 2, New York, William Wood & Company, 1928.

62 Cunningham, D. J. *Textbook of Anatomy*, edited by J. C. Brash and E. B. Jamieson, ed. 8, New York, Oxford University Press, 1943.

63 Cunningham, D. J. *Manual of Practical Anatomy*, ed. 8, New York, Oxford University Press, 1927.

64 Grant, J. C. B. *Method of Anatomy*, ed. 2, Baltimore, Williams & Wilkins Company, 1943.

65 Grant, J. C. B. *Atlas of Anatomy*, Baltimore, Williams & Wilkins Company, 1943.

66 (a) Browne, E. *Variations in Origin and Course of the Hepatic Artery and Its Branches*, *Surgery* **8**: 424, 1940. (b) Edwards, L. F. *The Retroduodenal Artery*, *Anat. Rec.* **81**: 351, 1941. (c) Pierson, J. M. *The Arterial Blood Supply of the Pancreas*, *Surg., Gynec. & Obst.* **77**: 426, 1943. (d) Petren, T. *Die Arterien und Venen des Duodenums und des Pankreaskopfes beim Menschen*, *Ztschr. f. d. ges. Anat.* (Abt. 1) **90**: 234, 1929. (e) Reeves, T. B. *Study of Arteries Supplying Stomach and Duodenum and Their Relation to Ulcer*, *Surg., Gynec. & Obst.* **30**: 374, 1920. (f) Ramodnawska, Z. *Die Arterien der Bauchspeicheldrüse*, *Ztschr. f. Anat. u. Entwicklungsgesch.* **79**: 506, 1926. (g) Wilkie⁴³. (h) Wilson, E. *A System of Human Anatomy*, edited by W. H. Gobrecht, Philadelphia, Blanchard & Lea, 1859. (i) Yule, E. *The Arterial Supply to the Duodenum*, *J. Anat.* **61**: 345, 1927.

67 Wilmer, H. A. *The Blood Supply of the First Part of the Duodenum*, *Surgery* **9**: 679, 1941.

tate was as a rule utilized in following the course of proximal larger vessels. For determination of the detailed distribution of the vasa recta to the duodenum, they were often cannulated by means of blunted hypodermic needles of small size and injected with india ink from a 5 cc syringe. In cases in which anterior and posterior pancreaticoduodenal arcades of the usual type were not present, the ligated gastroduodenal and superior mesenteric arteries were injected at their origins to allow contrast filling of the replacing vessels and facilitate their study. Unless otherwise specified, percentages stated are derived from this series of cases. Corroborative or explanatory references are indicated most often by number alone.

A Arteries to the First Part of the Duodenum—Wilkie⁶⁸ first definitively described the supraduodenal artery, usually stemming from the gastroduodenal or hepatic arteries, as the source of supply to roughly the upper two thirds of the anterior and one third of the posterior wall of the first part of the duodenum. He noted also that the upper part of the first $\frac{1}{2}$ inch (1.2 cm.) of the duodenum is supplied in about 50 per cent of cases by branches from the pyloric or right gastric artery. In most instances, as in our material, the supraduodenal artery is extremely narrow and would not appear to be the source of profuse hemorrhage in ulcer of the posterior duodenal wall, particularly since the larger branches pass anteriorly. Moreover in our and others'⁶⁹ material it is absent in a large minority if not the majority of cases. Recurrent branches from the right gastroepiploic or superior pancreaticoduodenal arteries supply the lower anterior part of the first inch (2.5 cm.) of the duodenum, the retroduodenal branches from the gastroduodenal artery supplying the posterior part. The supraduodenal artery is practically an end artery, and the anterior duodenal anemic spot of Mayo,⁷⁰ seen when the hepatoduodenal ligament is tensed, corresponds to the center of this relatively poorly supplied area. This deficient vascularity has been proposed by Wilkie⁶⁸ and Reeves^{66e} as a factor in the formation and chronicity of ulcer.

The supraduodenal artery could be identified and traced in some 70 per cent of the bodies in this series, as compared with one third of Thompson's^{69a} and 20 per cent of Browne's^{69a} series, and coursed anterior to or to the left of the common bile duct in the hepatoduodenal ligament. As recently emphasized by Browne^{69a} and others, this artery proves a frequent source of bleeding in choledochostomy and may be

68 Wilkie, D. P. D. Some Functions and Surgical Uses of the Omentum, *Brit. M. J.* 2:1103, 1911.

69 (a) Thompson, J. M. Arteries in Hepatic Pedicle, *Univ. California Publ. Anat.* 1:55, 1933. (b) Browne^{69a}.

70 Mayo, W. J. Anaemic Spot on the Duodenum, *Surg., Gynec. & Obst.* 6:600, 1908.

injured when the common duct is exposed and incised. If, however, damage to this vessel is a major factor in the development of duodenal ulcer, as postulated by several authors, operative procedures on the supraduodenal portion of the common bile duct should frequently be followed by this complication. Figures on the actual incidence of peptic ulcer following such operations are not available in the literature, but it is our clinical judgment that postoperative results do not bear out this premise. In our material the origins of the supraduodenal artery were gastroduodenal artery in 60 per cent, common or right or left hepatic artery in 25 per cent, right gastric artery in 12 per cent, superior pancreaticoduodenal artery in 6 per cent, cystic artery in 3 per cent and hepaticogastroduodenal anastomosis in 3 per cent. In cases in which the supraduodenal artery was of negligible size or could not be demonstrated there were multiple retroduodenal branches of the gastroduodenal artery and the right gastric artery generally contributed larger twigs than usual to the upper part of the first $1\frac{1}{2}$ inches (3.7 cm.) of the duodenum or the recurrent branches from the right gastroepiploic

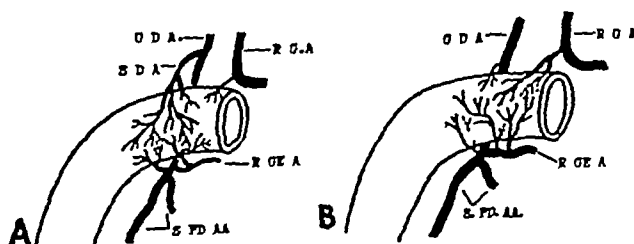


Fig 1—A, arteries to the first part of the duodenum, and B, usual distribution in absence of supraduodenal artery. GDA indicates the gastroduodenal artery, SDA the supraduodenal artery, RGA the right gastric artery, RGEA, the right gastroepiploic artery, and SPDAA the superior pancreaticoduodenal arteries.

artery, coming from below, almost encircled the duodenum instead of terminating in its lower half.

B. Arteries to the Second and Third Parts of the Duodenum.—The anterior and posterior pancreaticoduodenal arches are the major sources of arterial supply to the second and third parts of the duodenum⁷¹ and were present as such in 75 per cent of our dissections. These arches represent an anastomatic junction between the celiac axis and the superior mesenteric artery. Stemming superiorly from the anterior and posterior pancreaticoduodenal branches, which generally originate separately, of the gastroduodenal artery and below as a rule from the anterior and posterior branches of a single inferior pancreaticoduodenal branch from the superior mesenteric artery, the arcades from their con-

⁷¹ Kellogg, E. L. *The Duodenum*, New York, Paul B. Hoeber, Inc., 1933.
Pierson^{60c} Petren^{60d} Wilmer,⁶⁷

veity give off the rami duodenales and from their concavity the pancreatic branches. The latter act as guy ropes, securely fastening the arches to the head of the pancreas. The posterior arches are more apt to develop secondary or tertiary arcades before giving off the vasa recta. Much the same as with the marginal arterial arcade of the colon, these anastomoses lie at a variable distance, that is, from 15 mm to 6.5 cm from the medial border of the duodenum, with consequent variation in the length of the duodenal vasa recta. In the majority of cases, however, the distance was 3.5 cm or less. The pancreaticoduodenal arcades may thus encircle the head of the pancreas or lie close to the pancreaticoduodenal groove. The upper two thirds of the anterior and posterior divisions need not be similarly placed with respect to the duodenum and the pancreas. The anterior arch in its lower third descends to the pancreaticoduodenal groove in about 60 per cent of cases⁷² and the posterior in only 5 per cent. The vasa recta, before reaching the duodenum, may exhibit a moderate curve but, unlike the arcades proper, are never tortuous and are usually closely applied to the head of the pancreas as they cross it, almost as though that organ had expanded within the arcades and its branches, putting them on the stretch. Consequently, in an attempt to separate the duodenum from the pancreas, the small straight branches are immediately tensed and, no give being allowed, usually tear across readily, even with a centimeter of separation. Occasionally the anterior or posterior arches and a variable length of the rami duodenales are partly buried within pancreatic tissue or overlaid by a projecting fold of pancreas in the pancreaticoduodenal groove, making separation even more difficult. The lowermost part of the anterior arcade, as might be expected, most commonly burrows into pancreatic tissue since the inferior pancreaticoduodenal artery springs usually from a point on the superior mesenteric artery posterior to the pancreatic neck.⁷³

In 25 per cent of our specimens a complete arterial circle was lacking. In 14 per cent of the bodies examined, the inferior pancreaticoduodenal artery, less constant than the superior in its course, did not meet the anterior superior pancreaticoduodenal artery in an anastomosis of any size but broke up into numerous branches, some entering the pancreas and others supplying primarily the third part of the duodenum. In several of these cases, however, the posterior arcade was more completely developed. In 6 per cent of cases a direct anastomotic trunk was replaced by a series of arcades resembling those of the mesenteric circulation, both anteriorly and posteriorly in most, from the terminal loops of which originated the vasa recta to the duodenum, with pan-

72 Piersol⁴ Petren^{66d}

73 (a) Ziegler, H. R. Excision of the Head of the Pancreas for Carcinoma, Surg., Gynec. & Obst. 74 137, 1942. (b) Pierson^{66c}

creatic branches stemming from the primary and other loops Wilmer⁶⁷ described as a relatively constant structure, on the apparent basis of only a few specimens, a gastroduodenal plexus of relatively large arteries. These he stated, form an additional two separate arcades, each arising from the gastroduodenal and superior mesenteric arteries respectively, and lie posterior to the duodenum, with liberal intercommunications between the two. In our material, this plexus could not be clearly demonstrated as such. Wilmer⁶⁷ advanced the opinion that this arterial plexus was frequently involved in the massive hemorrhage of duodenal ulcer. With this in mind we made a particular effort to find such a plexus of vessels of large caliber behind that portion of the first described part of the duodenum corresponding to the "bulb," or cap, the prevalent site, according to pathologic descriptions, of bleeding duodenal ulceration. It was only in the few instances in which both pancreaticoduodenal arches coursed mainly in the pancreaticoduodenal grooves that a plexus of vessels of notable size was found closely approximated to the posteromedial duodenum, and there only in its second part. In these cases, numerous good-sized anastomoses between the anterior and posterior arches were often but not invariably present. In only 5 per cent of our dissections a true third pancreaticoduodenal arcade could be found in the groove medial to the second part of duodenum in addition to the usual anterior and posterior arches encircling the head of the pancreas. In a review of the autopsy records of several cases of fatal hemorrhage from duodenal ulcer, the often reiterated fact that the gastroduodenal or the superior pancreaticoduodenal artery was eroded⁷⁴ and projected into the ulcer bases was confirmed by us. Wilmer's⁶⁷ studies were based on an injection-corrosion technic, so the possibility exists that the anastomoses of large caliber referred to might be intramural. The usual absence of extensive intramural duodenal arterial anastomoses is, however, pointed out by us and other observers⁷⁵. It is perhaps noteworthy that in several articles on the pancreatic circulations other authors⁷⁶ cited Wilmer's findings without giving any descriptive confirmation in presenting their own.

74 (a) Boyd, W. B. *Surgical Pathology* Philadelphia W. B. Saunders Company, 1942. (b) Eliason, E. L., and Johnson, J. *Surgical Aspects of Gastrointestinal Hemorrhage*, Proc. Interst. Postgrad. M. A. North America (1940), 1941, pp. 312-318. (c) Finsterer³⁹. (d) Nissen³¹. (e) Thorstad, M. J. *Problem of Bleeding Peptic Ulcer*, Surgery **12** 964, 1942. (f) Wangenstein¹⁹.

75 (a) Cokkinis, A. J. *Observations on the Mesenteric Circulation*, J. Anat. **64** 200, 1930. (b) Eisberg, H. B. *Intestinal Arteries*, Anat. Rec. **28** 227, 1924.

76 Portis, S. A. *Diseases of the Digestive System*, Philadelphia, Lea & Febiger, 1944. Ziegler^{73a}.

C Arteries to the Fourth Part of the Duodenum—The superior mesenteric artery, the inferior pancreaticoduodenal artery and the first jejunal artery generally contribute twigs to the fourth part of the duodenum. The duodenojejunal flexure itself likewise receives twigs from at least two of these three sources. Pierson^{66c} found that the first

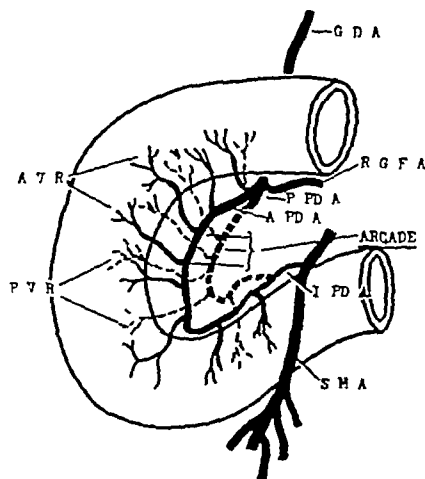


Fig 2—The peripancreatic pancreaticoduodenal arterial arcade. This was present in about 75 per cent of the cases. *GDA* indicates the gastroduodenal artery, *RGEA*, the right gastroepiploic artery, *PPDA*, the posterior pancreaticoduodenal artery, *APDA*, the anterior pancreaticoduodenal artery, *IPDA*, the inferior pancreaticoduodenal artery, *SMA*, the superior mesenteric artery, *AVR*, the anterior vasa recta, and *PVR*, the posterior vasa recta.

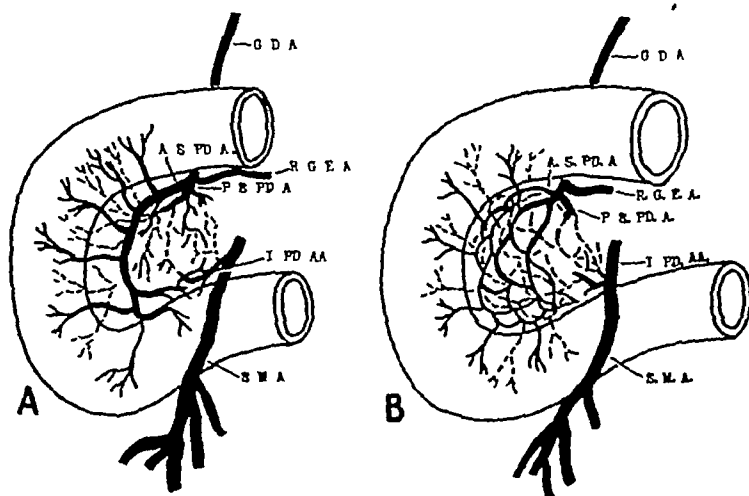


Fig 3—Common variants in pancreaticoduodenal arterial circulation. *A*, anterior arcade partly complete, with inferior pancreaticoduodenal and postero-pancreatic arteries branching (present in about 15 per cent of the cases). *B*, mesenteric arcade and branching pattern (present to some extent in 10 per cent of the cases). *GDA* indicates the gastroduodenal artery, *ASPD A*, the anterior superior pancreaticoduodenal artery, *PSPD A*, the posterior superior pancreaticoduodenal artery, *RGEA*, the right gastroepiploic artery, *IPDAA*, the inferior pancreaticoduodenal artery, and *SMA*, the superior mesenteric artery.

jejunal artery made only a minor contribution and suggested excision of the proximal 1 or 2 inches (2.5 to 5 cm) of the jejunum when the other branches are destroyed. In over half of our cases, however, the twigs from the first intestinal and superior mesenteric arteries seemed to be of fair size. In 5 specimens, there was a short trunk, giving off equal-sized duodenal and jejunal branches, in other words, a duodenojejunal first intestinal artery was present.

D The Arteries of Origin of the Pancreaticoduodenal Arcades—The gastroduodenal artery descends medial or anterior to the lower common duct behind the first part of the duodenum and at its inferior border divides into the inferior gastroduodenal and anterior superior pancreaticoduodenal arteries. During this course it gives off the supraduodenal, posterior and superior pancreaticoduodenal, retroduodenal and pancreatic branches and occasionally the supraduodenal artery. In 2 cases a cystic, in 1 an accessory and in 2 a replacing right hepatic artery came from the gastroduodenal artery, a not uncommon finding. The

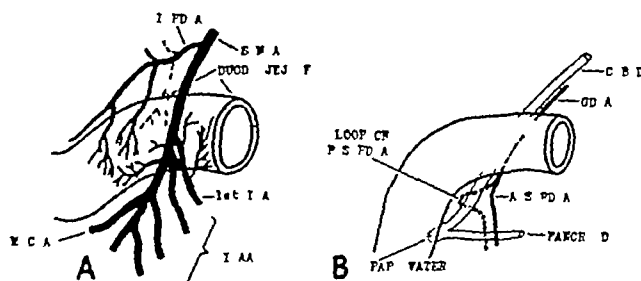


Fig 4—A, arteries to the fourth part of the duodenum. *IPDA* indicates the inferior pancreaticoduodenal artery, *DUOD JEJ F* the duodenojejunal flexure, *SMA*, the superior mesenteric artery, *1st IA*, the first intestinal artery, *IAA*, the intestinal arteries, and *MCA*, the middle colic artery. B, looping of posterior superior pancreaticoduodenal artery about common bile duct. *CBD* indicates the common bile duct, *GDA*, the gastroduodenal artery, *PANCR D*, the pancreatic duct, and *PAP VATER* the papilla of Vater.

gastroduodenal artery is a fairly constant trunk^{66a} and is almost always a branch of the common hepatic artery or, as in 4 specimens, of the right or left hepatic arteries near their origin. Browne^{66a} pointed out that there is never duplication of this trunk. Del Campo⁷⁷ stated that it may rarely arise from the superior mesenteric or celiac arteries or have a double origin. It is of somewhat narrower caliber than the right gastroduodenal artery. In 1 case the inferior pancreaticoduodenal replaced an absent gastroduodenal artery. In 2 instances of our series it arose directly from the celiac axis,⁷⁸ and in 1 case the hepatic artery came from the superior mesenteric artery, which had a common trunk or

77 Del Campo, J. C. *Circulacion del duodeno*. An. de Fac. de med. Montevideo 12: 404, 1927.

78 Eaton, J. *Celiac Axis*, Anat. Rec. 13: 423, 1917.

origin with the celiac arterial axis⁷⁹ and gave off a short, retroduodenally situated gastroduodenal artery. Lipschutz⁸⁰ reported this anomaly of a common origin of the superior mesenteric and celiac axes as normal in certain lower mammals and occurring in about 2.5 per cent of human beings. In 1 case the main and in 1 other an accessory middle colic artery, with both from celomesenteric axes, came from the gastroduodenal artery, an infrequent but probably not rare anomaly that has also been described by Ziegler^{73a}. Pierson^{80c} described an instance of a middle colic artery originating from the superior pancreatic artery. The operative complication of ischemic necrosis of the transverse colon, which has been reported occasionally to follow gastrectomy,^{80a} may thus in some cases be due to an anomalous origin of the middle colic artery from a ligated gastroduodenal artery rather than to secondary injury of a normal middle colic artery lying close to the right gastroepiploic artery in its passage adjacent to the duodenal artery during ligation of the latter vessel. The following developmental mechanism is postulated to account for the occurrence of this atypical condition. The frequent embryologic existence in the primitive vascular bed of anastomotic channels between main arterial branches near their origin from a common trunk is well recognized. The paraduodenal arterial anastomosis between the superior and inferior mesenteric arteries reported in one third of the bodies⁸¹ can be considered as an example of the persistence of such an arch. With the anomaly of a celomesenteric axis,⁸⁰ such anastomoses between colic and duodenal circulations are thus understandable. The majority of such channels become obliterated as development proceeds, but that is not always the case as borne out by the presence of a gastroduodenal hepatic anastomotic trunk in 6 per cent of the bodies. In an infrequent instance the primary segment of origin of a branch may in some way become occluded, and in such a case a persistent anastomotic arch would provide an anomalous origin, i.e., a middle colic from a superior pancreatic or a gastroduodenal artery. Similarly, the commoner occurrence (15 per cent) of a middle colic artery originating from an inferior pancreaticoduodenal vessel or vice versa may be explained. Steward and Rankin⁸² dismissed the observa-

79 Fetterolf, G. Variations in the Arteries of the Human Body, Univ Pennsylvania M. Bull. **21** 323, 1908-1909.

80 Lipschutz, B. A Composite Study of the Coeliac Axis. Ann Surg **65** 213, 1917.

80a Yovanovitch, B. Y. Le probleme chirurgical de la blessure de l'artere colique moyenne au cours des operations sur l'estomac, Progrès med., 1938, p. 1285.

81 do Carmo Russo, A. Sobre o "arco vascular de Treitz" e a anastomose paraduodenal entre as duas arterias mesentericas, An. Fac. de med. da Univ. de São Paulo **17** 105, 1941.

82 Steward, J. A., and Rankin, F. W. Blood Supply of the Large Intestine, Arch Surg **26** 843 (May) 1933.

tion of Wilson^{66b} of a single case of a middle colic artery originating from a hepatic artery as embryologically unsound. However, they cited no variant origins of the gastroduodenal superior mesenteric or inferior pancreaticoduodenal arteries, frequently noted by us and others, in their dissections of the middle colic vessels. It is noteworthy that the splenic artery gives no branches to the duodenum or head of the pancreas, even atypically, a finding confirmed by several observers.

The anterior superior pancreaticoduodenal artery was present in all cases but 1, in which it was replaced by large branches from the inferior pancreaticoduodenal artery and came off the gastroduodenal artery just above the lower wall of the first part of the duodenum.

The posterior superior pancreaticoduodenal artery generally originates from the right dorsal side of the gastroduodenal artery and in 75 per cent of the cases as it descends crosses anteriorly to the right of the retroduodenal common bile duct, curves round it and, crossing it dorsal to its intrapancreatic portion, descends toward the left, thus usually forming an arterial hook around the duct,^{66c, d} contributing to it several small branches at the same time^{66c, d}. One or more of these twigs extend along the common duct and may form an accessory cystic duct.⁸³ Injury to these vessels may lead to localized ischemic injury or necrosis of the common bile duct. It is now well appreciated that in roughly 15 per cent of cases the right hepatic artery crosses the cystic duct or neck of the gallbladder.⁸⁴ A matter not so generally known, however, is that in some 10 per cent of persons the normal common hepatic artery comes within 1.5 cm of the superior duodenal border or that an anomalous accessory or replacing right hepatic artery in another 10 per cent passes behind the duodenum and might be injured in a careless mobilization of the duodenal stump. In a small percentage of cases, the supraduodenal or, more often, replacing arteries to the first part of the duodenum stem from the superior pancreaticoduodenal arteries. The superior pancreaticoduodenal may arise from the hepatic artery.⁷⁹

The inferior pancreaticoduodenal arteries arise in a common trunk in 70 per cent of cases, generally from the posterior aspect of the superior mesenteric arteries, usually above the lower border of the neck of the

83 Del Campo⁷⁷ Pierson^{66c}

84 Branco, D. R. *Tonic coeliaque et ses branches de l'artere hepatique*, Paris, G. Steinheil, 1912. Browne,^{66a} Brewer, G. E. *Some Observations upon the Surgical Anatomy of the Gall Bladder and Ducts*, in *Contributions to the Science of Medicine*, Dedicated by His Pupils to William Henry Welch on the Twenty-Fifth Anniversary of His Doctorate, Baltimore, Johns Hopkins Press, 1900. Flint, E. R. *Abnormalities of the Right Hepatic, Cystic and Gastroduodenal Arteries and of Bile Ducts*, *Brit J Surg* **10** 509, 1923. Landner, H., Lyman, R. Y., and Anson, B. J. *An Anatomical Consideration of the Structures in the Hepatic Pedicle*, *Quart Bull Northwestern Univ M School* **15** 103, 1941.

pancreas but occasionally from a high retropancreatic position, rendering ligation difficult early in pancreatectomy⁸⁵ In 20 per cent the first intestinal or jejunal arteries are the source in a common duodeno-jejunal trunk, a finding reported also by Ramodnawska^{66f} In 12 per cent the middle colic artery may come off the inferior pancreaticoduodenal artery or provide its origin, since the two may have a common trunk Despite the fact that the inferior pancreaticoduodenal arteries

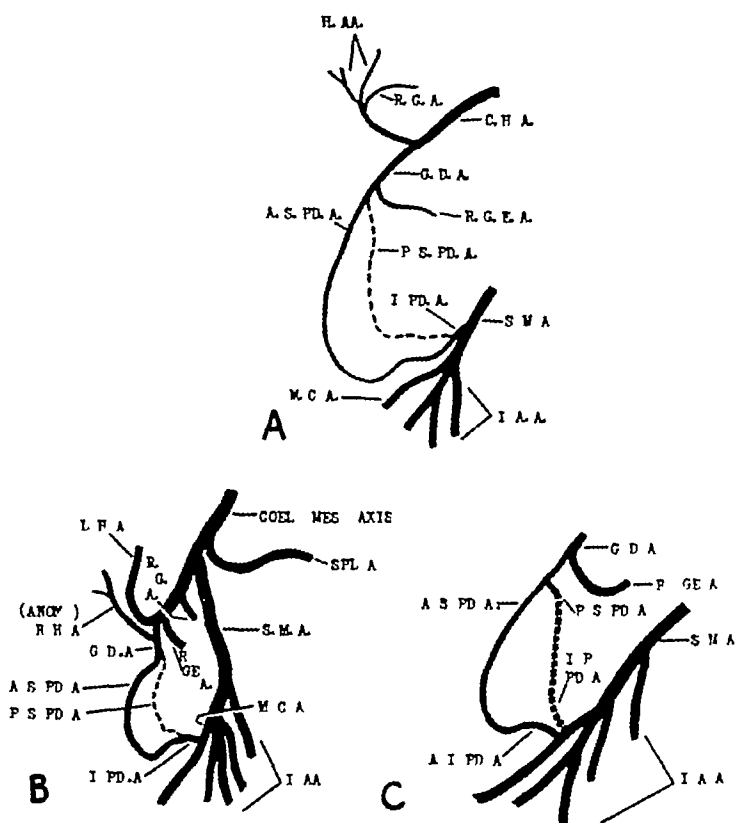


Fig 5—Origins of the pancreaticoduodenal arcades *A*, usual origins *B*, common variant (about 15 per cent) *C*, unusual anomaly *H.A.A.* indicates the hepatic arteries, *R.G.A.*, the right gastric artery, *C.H.A.*, the common hepatic artery, *G.D.A.*, the gastroduodenal artery, *R.G.E.A.*, the right gastroepiploic artery, *A.S.P.D.A.*, and *P.S.P.D.A.*, the anterior and posterior superior pancreaticoduodenal arteries, *I.P.D.A.*, the inferior pancreaticoduodenal artery, *S.M.A.*, the superior mesenteric artery, *M.C.A.*, the middle colic artery, *I.A.A.*, the intestinal arteries, *COEL MES AXIS*, the celiacomesenteric axis, *S.P.L.A.*, the splenic artery, and *L.H.A.*, the left hepatic artery

are reported as less constant than the superior,^{78a} they were present in all our cases, although, as already mentioned, in 14 per cent they branched in multiple fashion, without entering into arcade formation

⁸⁵ Brunschwig, A. *Surgery of Pancreatic Tumors*, St Louis, C V Mosby Company, 1942 Ziegler^{78a}

It should be noted, as illustrated in the accompanying schematic diagram, that the vascular relationships of the duodenum are such that injury to the normal or anomalous hepatic, middle colic, superior mesenteric or gastroduodenal arteries, the portal vein or the common bile or pancreatic ducts should be guarded against in mobilization of the duodenum, particularly in cases of difficult operation

C Configuration of the Vasa Recta at the Region of the Duodenal Stump—The rami duodenales supplying the portion adjacent to and including the flexure between the first and second parts of the duodenum present pronounced configurational variations. The commoner patterns encountered and their approximate percentage of occurrence are here noted. The commonest is an arrangement of roughly parallel rami branches of the upper parts of anterior and posterior pancreaticoduodenal arcades alternating singly or in pairs, spaced an average of 1.5 cm

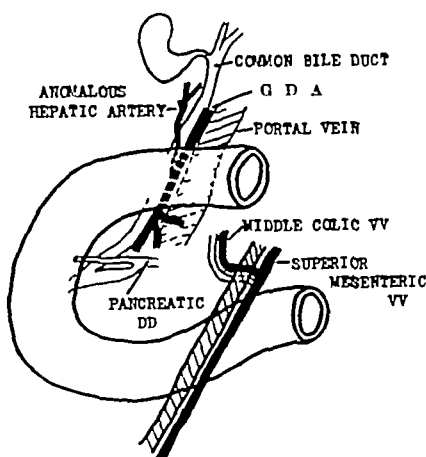


Fig 6—Schematic illustration of major structures to be avoided in duodenal stump mobilization. *G D A* indicates the gastroduodenal artery, *VV*, vessels, and *PANCREATIC DD*, the pancreatic ducts

apart. In about 25 per cent of cases, the extrinsic branches are spaced 2 to 3 cm or more apart but branch just before reaching the duodenum. In one sixth of the cases the intestinal arteries to the duodenum are represented by four or more somewhat larger twigs, which sweep across the duodenum nearer its pancreatic border and provide vascularity for some 7 to 9 cm of duodenum. This last pattern has been illustrated without textual comment by Pierson^{60c}, Petren^{60d}, Grant⁶⁴ and Reeves^{60e}. As can readily be seen from the illustrative sketches, laceration of the vasa recta in cases in which it is sparsely distributed, in separation of duodenum from pancreas would lead to a greater degree of ischemia than usual and is apt to be followed by extensive necrosis of the stump. As mentioned elsewhere, identical technics of handling the duodenal stump might thus lead to blow-out in just the cases in which the

arterial configuration was such that relatively little dissection in the pancreaticoduodenal groove would devascularize 3 cm or more of retained duodenum or in which so long a segment of duodenum with normal vasa recta distribution is separated from pancreas that 3 to 5 cm sustains laceration of arterial branches

F Arterial Relationships and Supply of the Common Bile Duct and Their Surgical Significance—The intrinsic arterial blood supply of the ductus choledochus proper has received scant attention and that

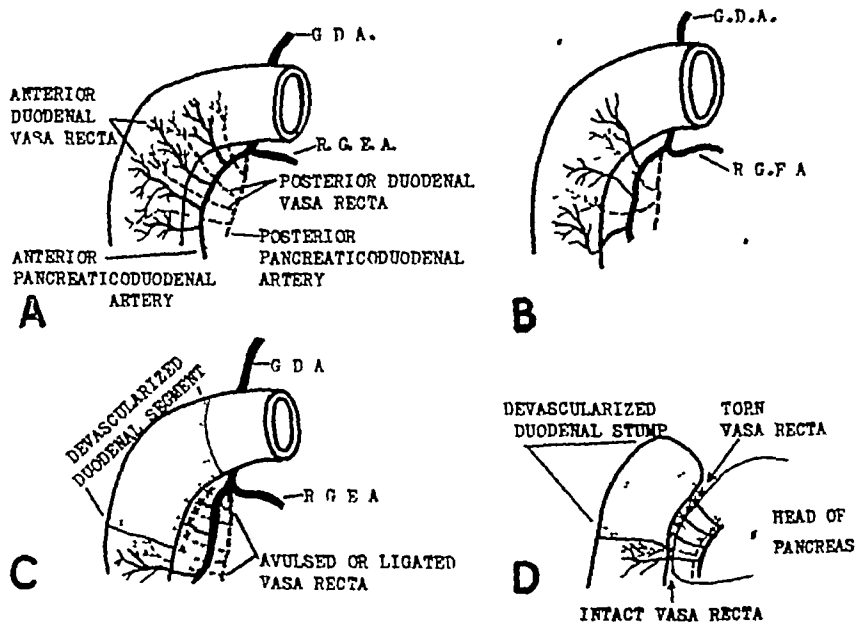


Fig 7—Variations in configuration of the vasa recta at the region of the duodenal stump *A*, usual pattern *B*, widely spaced "blow-out" pattern *C*, devascularization of duodenal segment by avulsion of rami duodenales in separation of duodenum from head of pancreas *D*, extent of devascularized duodenal stump susceptible to ischemic necrosis resulting in many commonly adopted procedures for gastrectomy

primarily in the foreign literature. Resurgence of interest in such surgical procedures as plastic operations on the common duct and duodenopancreatectomy for carcinoma of the ampulla and head of the pancreas requires a somewhat detailed knowledge of the small arteries to this structure. No description at all of the arterial sources of supply to the common bile duct could be found in the twenty odd standard reference manuals of anatomy and surgical anatomy referred to several times previously.

The retroduodenal portion of the common duct usually receives three to five minute twigs from the superior posterior pancreaticoduodenal artery as it loops around the common duct. Except for one branch or occasionally two, these usually enter the wall of the duct

after a short external course. The remaining twig or twigs ascend along the medial border or to either side of the duct, in some instances terminating as an accessory cystic artery. The supraduodenal artery in two of the few instances in which it was a relatively large vessel gave a discernible branch to the lower part of the common duct, but here the unusually large supraduodenal artery notably overlapped the region of duodenum usually supplied by the superior pancreaticoduodenal arteries. The right hepatic artery contributes several small branches to the central and upper sections⁸⁶ of the ductus choledochus with relative constancy, and the gastroduodenal artery contributes to the lower third. The cystic arteries likewise send minute vessels to the

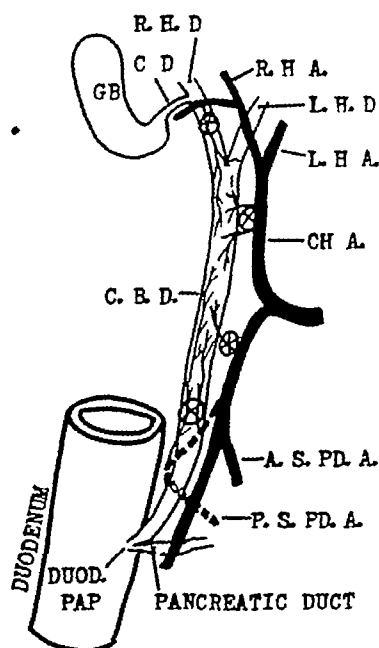


Fig 8—Sketch of the most frequent arterial twigs to ductus choledochus. Crossed circles indicate the sites of possible avulsion of end arteries in manipulations and exposures incident to operation on the common duct. GB indicates the gallbladder, C.D., the cystic duct, CH.A., the common hepatic artery, C.B.D., the common bile duct, A.S.P.D.A. and P.S.P.D.A., the anterior and posterior superior pancreaticoduodenal arteries, and DUOD. PAP., the duodenal papilla. (Note low bifurcation of ductus, present in 15 to 20 per cent.)

upper part of the common duct and occasionally provide a fair-sized twig or twigs descending along it. The lower veins drain into the portal via the posterior superior pancreaticoduodenal vein. Petren⁸⁷

86 Faure, J. L. Quelques points de l'anatomie des voies biliaires, Thesis Paris, 1898.

87 Petren, T., and Karlmark, E. Die extrahepatischen Gallenwegsvenen und ihre pathologische-anatomische Bedeutung, Verhandl. d. anat. Gesellsch. 41: 139, 1932.

disagreed with Rouvière,⁴⁷ who stated that the cystic veins drain into the portal, and illustrated venous drainage of both gallbladder and most of the common duct ascending into the liver and entering the hepatic vein radicles directly. In several bodies we found that the injection of the portal vein filled only the venules of the retroduodenal portion of the common duct, in confirmation of Petren's observation.

The common bile duct in rudimentary fashion resembles the small intestine in its structure. The mucosal lining, muscularis and serosa of the 75 cm long duct would appear to require an adequate circulation for viability no less than similar tissue elsewhere. In the wealth of literature on hepatic and common duct injuries following operation in this region, the possible role that devascularization in stripping a large surface of these ducts for exposure might play in the formation of biliary passage stricture and fistulas or in the failure of duct reconstructions and choledochointerostomies does not appear to have been given any consideration. In our material, the minute branches supplying the common duct showed great variation in distribution patterns. Anastomotic marginal arteries running the length of the common duct and insuring adequate circulation, with relatively complete stripping of the ducts, could only occasionally be demonstrated. More often than not small blood vessels approaching at right angles to the common duct appeared to serve as end arteries for several centimeters of duct length and were so arranged that widespread separation of the hepatic arteries and other structures in the hepatoduodenal ligament might lacerate these relatively fine trunks. To what extent such manipulation might result in localized ischemic necrosis and later unexpected stricture formation or fistulas is a problem for the solution of which experimental investigation is indicated. Minimal surface exposures to reduce the dangers of such devascularization in operations on the common duct are probably advisable in most circumstances.

G Arterial Supply of the Pancreas—For purposes of completeness, a brief review of the pancreatic circulation is included in this paper.⁸⁸ Typically, the head of the pancreas is supplied by the anterior and posterior superior pancreaticoduodenal arteries, anastomosing in arcade fashion with the anterior and posterior inferior pancreaticoduodenal arteries. A superior pancreatic artery, generally arising from the splenic, hepatic or celiac arteries, passes dorsal to the neck of the pancreas and gives off left and right branches. An inferior pancreatic artery from the superior mesenteric, superior or anterior pancreaticoduodenal or superior pancreatic arteries runs posteriorly along the inferior border of the body of the pancreas. Both superior and inferior

88. (a) Wharton, G. K. Blood Supply of the Pancreas, *Anat Rec* 53:55, 1932. (b) Pierson *et al*

arteries may course within the gland. The splenic and gastroduodenal arteries likewise contribute several pancreatic branches.

H Venous Drainage of the Duodenum and Pancreas—The veins usually lie superficial to the arteries. According to both Pierson^{88c} and Wharton,^{88a} the outer, or superior, pancreaticoduodenal vein drains constantly into the right gastroepiploic and thence into the superior mesenteric. The posterior superior pancreaticoduodenal vein almost always drains directly into the portal. The inferior or pancreaticoduodenal veins empty generally into the superior mesenteric and the posterior occasionally into the anterior mesenteric vein or, as in 2 of our cases, into the splenic veins. It is worth repeating here, however, that by contrast the splenic and duodenal arterial circulations were in all instances completely independent, a finding commented on also by Michels.⁸⁹

I Arterial Anastomoses about the Site of Bleeding Duodenal Ulcers—Review of the literature on the surgical approach to bleeding duodenal peptic ulcer reveals a current trend toward subtotal gastrectomy as the operation⁹⁰ of choice. However, ligations are still described as alternative procedures⁹¹ and often attempted, particularly by the occasional operator. Although a few articles mention its questionable adequacy and the difficulties besetting ligation, little detail is given. It is felt that schematic illustration of the right arterial anastomotic pattern involved is warranted to demonstrate the impracticability of attempts at ligation in most instances of bleeding ulcer in which operation has been decided on. It is not the purpose of this paper to enter the controversy concerning the merits of medical versus surgical therapy. Thorstad stated that duodenal ulcers are more frequently the source of hemorrhage than are gastric ulcers and that the bleeding posterior duodenal ulcer is the more likely to prove fatal. Massive hemorrhage, as discussed earlier in this paper, results when the pancreaticoduodenal or gastroduodenal arteries in the posterior wall of the duodenum or the left gastric artery and the gastroepiploic artery in the posterior wall of the stomach are eroded and prevented from retraction by chronic inflammatory induration of the ulcer bed or sclerosis of the arterial wall.

89 Michels, N. A. Variational Anatomy of the Spleen and Splenic Artery, *Am J Anat.* **70** 21, 1942.

90 (a) Bohrer, J. V. Massive Gastric Hemorrhage, *Ann Surg.* **114** 510, 1941. (b) Eliason and Johnson.^{74b} (c) Finsterer.⁸⁹ (d) Gordon-Taylor, G. Attitude of Surgery to Haematemesis, *Lancet* **2** 812, 1935. (e) Thorstad.^{74e} (f) Welch, C. S., and Yunich, A. M. Problem for Surgery in Massive Hemorrhage of Ulcer Origin, *Surg., Gynec. & Obst.* **70** 662, 1940. (g) Wilkie.⁶⁵

91 Bohrer.^{89a} Welch and Yunich.^{80f} Thorstad.^{74e}

Ligations necessary to control bleeding from duodenal ulcers eroding the gastroduodenal artery or superior pancreaticoduodenal artery at the usual sites indicated would require isolation and occlusion of the gastroduodenal and inferior pancreaticoduodenal arteries at their origins and often the left gastroepiploic artery as well. Apart from the surgical difficulties encountered, this would be tantamount to complete devascularization of the duodenum and head at the pancreas, a procedure which the patient probably would not survive. Exclusion of the duodenum with plication of its wall to augment mass ligatures placed about the ulcer site, in somewhat the fashion suggested by Wangensteen,²⁰ would appear to be the only effective alternative in patients too desperately ill to withstand subtotal gastrectomy.

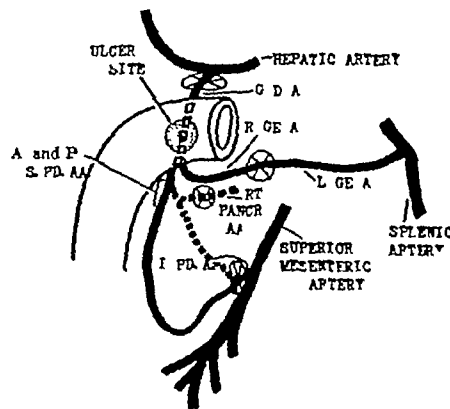


Fig 9—Schema of major arterial anastomoses to the usual bleeding site in massive hemorrhage of duodenal ulcer, illustrating difficulties of ligation. Crossed ellipses indicate necessary points of ligation for complete control of hemorrhage, performance of which would deprive duodenum and head of pancreas almost completely of blood supply. GDA indicates the gastroduodenal artery, RGEA, the right gastroepiploic artery, LGEA, the left gastroepiploic artery, A, and P, the anterior and posterior superior pancreaticoduodenal arteries, RT, the right pancreaticoduodenal artery, and IPDA, the inferior pancreaticoduodenal artery.

GENERAL FEATURES OF THE PROXIMATE ARTERIAL SUPPLY OF THE SMALL INTESTINE

Monks⁹² demonstrated that the mesenteric arcade network grows progressively more complicated as it proceeds from duodenum to cecum. From the ultimate arcades arise the vasa recta, which enter and ramify within the tunics of the wall of the bowel. A physiologic purpose of this complex vascular web is evidently that of providing an adequate collateral circulation whenever the direct vessels to a given loop are occluded by vigorous peristalsis or mesenteric kinking. Beaton

92 Monks, G. H. Intestinal Localization, *Ann Surg* 38:574, 1903.

and Anson,⁹³ in a detailed description of a single specimen, reported that in the proximal jejunioileum the number of arcade loops per 10 cm are seven to ten, becoming fourteen to sixteen distally. The vasa recta near the duodenum number only seventeen, but near the ileum are as high as thirty-two per 10 cm. However, the number of terminal artery branches are approximately the same at all levels, an average of forty-seven per centimeter, with more constant branching of the proximal than the distal vasa recta. In general, the arterial intestinales decrease in caliber distally as the plexuses increase in intricacy, and the more complicated the arterial reticulum the smaller the individual loops. As we note elsewhere, in duodenum proper the number of vasa recta average less than twelve per 10 cm, and there appears to be some decrease in terminal end arteries as compared with jejunioileum.

Eisberg,^{75b} in a minute study of the arrangement of arteries to the various coats of intestines, stated that vasa recta generally arise singly from the terminal mesenteric arcades and alternate more often than not, one passing in front of and the other behind the duodenum. Occasionally they bifurcate and alternate in pairs. Bifurcation and branching are occasional in the duodenum, greatly increasing in the ileum and decreasing again in the colon. In our specimens, branching was more pronounced in cases in which the vasa recta themselves were fewer. The vasa recta encircle the intestine, their deeper main branches converging toward the lumen. In passing between the serosa and muscularis they give off numerous lateral offshoots, which unite with tiny similar branches from adjacent arterioles. The vasa recta pierce the muscularis close to the mesenteric border in the small intestine but approach the antimesenteric border before so doing in the large intestine. Dragstedt and colleagues,⁹⁴ taking the cross section of the bowel as representing the face of a clock, described the anterior and posterior or right and left vasa recta as piercing the muscularis at approximately 5 and 7 in the duodenum, 3 and 9 in the jejunioileum and 2 and 10 in the colon, with 12 o'clock representing the antimesenteric or antivascular border. In the duodenum we find that the distribution should be referred to the pancreatic instead of the mesenteric border. The more superficial disposition and greater length of the latter vessels seem, according to us, related to the greater capacity for distention of the colon, with less interference with its blood flow. Noer⁹⁵ disagreed, stating that the greater tortuosity of the colonic intramural trunks might

93 Beaton, L. E., and Anson, B. J. The Arterial Supply of the Small Intestine, *Quart Bull Northwestern Univ. M. School* **16** 114, 1943.

94 Dragstedt, C. A., Lang, V. F., and Millet, R. F. The Relative Effects of Distention on Different Portions of the Intestine, *Arch Surg* **18** 2257 (June) 1929.

95 Noer, R. J. The Blood Vessels of the Jejunum and Ileum, *Am J Anat* **73** 293, 1943.

be a mechanism which protects against undue stretching in intestinal distention Gatch and Battersby⁹⁶ also disagreed, believing that the thicker duodenal mucosa is more affected by increased intraluminal pressure than the thinner ileal or colonic lining Toward the anti-mesenteric border or, as we have pointed out, above the "antipancreatic" border in the duodenum, the intramural vessels branch in delicate arborescent fashion Fine intramuscular arterial arcades and additional smaller direct branches from the terminal extramural arcades are frequent in the ileum but sparse in the duodenum This intramuscular anastomosis is a relatively poor one, however, the more plentiful anastomosis occurring between the finer twigs of the submucosa This lack of anastomosis of the larger twigs of the vasa recta within as well as without the wall of the duodenum proper was noted regularly in our material Eisberg^{70b} found that the length of the vasa recta from origin to mesenteric border varies from 1.5 to 3 cm in the duodenum, 3 to 3.5 cm in the jejunum and 1 to 2.5 cm in the distal ileum, where

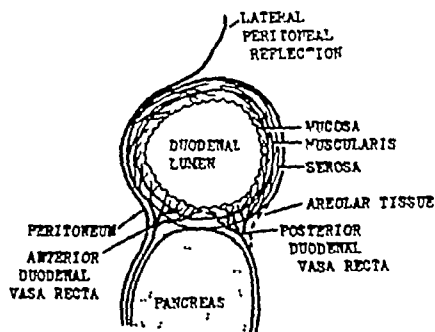


Fig 10—Schematic cross section of the duodenum and vasa recta, demonstrating the end artery character of vasa recta This indicates the absence of major marginal or intramural anastomotic branches

branching is the greatest Noer⁹⁵ described fine anastomoses at the mesenteric borders between mural branches of opposite side We found, however, that the length of the vasa recta in the duodenum depends on the position of the pancreaticoduodenal arcade, which may lie as far as 6.5 cm from the medial duodenal border

THE SAFETY FACTOR IN MESENTERIC LIGATION IN RELATION TO VASA RECTA AS FUNCTIONAL END ARTERIES

Of paramount importance in intestinal operation is the preservation intact of the intrinsic blood supply of the segments involved Welsh and Mall are quoted by Eisberg⁹⁷ as having demonstrated that if more

⁹⁶ Gatch, W. D., and Battersby, J. S. The Two Stages of Bowel Distention, *Arch Surg* 44:108 (Jan) 1942

⁹⁷ Eisberg, H. B. Viability of the Intestine in Intestinal Obstruction, *Ann Surg* 81:926, 1925

than 5 cm of intestine was separated from its blood supply gangrene would result. In Eisberg's⁹⁷ own experiments on dogs if the vasa recta and smaller arteries were ligated, gangrene invariably followed if more than 3 cm of contracted intestine were devascularized. Ligation of four duodenal vasa recta induced gangrene of the segment. It should be remarked that the central areas underwent necrosis even though normally vascularized tissue was present 2 cm to either side of it to provide possible collateral circulation. In the case of the inverted apex of the stump of the severed duodenum stripped of its blood vessels for a distance of 3 to 4 cm, with an adjacent area of well vascularized intestine twice as far away and on one side only, ischemic necrosis should be even more certain. Since it is well established that great distention reduces capillary and later arteriolar blood flow, leading to ultimate hemorrhage and necrosis of intestinal wall,⁷ this happening would produce gangrene in cases in which borderline sufficiency of the duodenal stump circulation obtains.

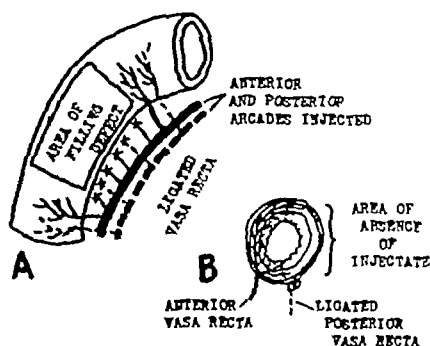


Fig 11—Nonfilling of ligated vasa recta of the duodenum on injection of cannulated adjacent arcades and vasa recta. Experimental demonstration of the end artery character of the rami duodenales. A, longitudinal segment. B, cross section.

Eisberg⁹⁷ concluded that the margin of safety with human intestine after ligation or injury of mesenteric vessels was greatest in the second arcade row away from intestine. He also stated the belief that the factor of safety was greater in the jejunum and ileum than in the duodenum and colon but stated that the lack of mesenteric arcades in these locations was compensated for by fixation of these parts of the intestinal canal. With ligation of contiguous vasa recta, injection fluid introduced into the pancreaticoduodenal artery did not inject the interrupted vasa recta, indicating a lack of intramural anastomotic twigs of significant size. If more than one of the vasa recta were ligated, injection fluid did not appear in adjacent vessels. This was confirmed in our anatomic specimens, when duodenal extramurally ligated vasa recta in recently dead bodies were not filled on direct

injections with india ink of adjacent vasa recta, with the use of hypodermic syringe pressures certainly greatly exceeding the usual intestinal intramural blood pressures. By contrast, an intramural arteriolar anastomosis at the mesenteric border produced such filling relatively often in ileal rami intestinales. The extramural anastomotic system between vasa recta at the mesenteric border of small intestine described by Eisberg^{75b} could not be demonstrated in the small intestine of any of our specimens, whereas the presence of the frequently described⁹⁸ marginal artery of the colon was readily confirmed in most bodies. Noer,⁹⁵ in a recent study, similarly failed to find intercommunications from the human vasa recta during their course from the peripheral arcades to the intestinal wall. Cokkinis,^{75a} injecting india ink in a technic similar to ours, observed no anastomoses between arborescent vessels in the human intestinal walls or between vasa recta. In effect, the human vasa recta in the duodenum would appear to be functional end arteries to probably a greater degree than those in the jejunum and, judging from our material, less abundantly distributed. Morton⁹⁹ claimed the existence of a larger caliber of anastomotic vessel and a richer capillary supply in the duodenum than in the ileum of the dog. In his experiments, he injected the thoracic aorta with barium mixtures and used roentgenograms for illustration. As direct injection of india ink into the trunks of the main intestinal artery in human beings by us failed to reveal a more extensive anastomotic capillary rete, we conclude that in addition to differences in animals under the experimental conditions cited by Morton, effective injection pressures of material introduced into the aorta might not be the same for the higher, more direct branches of the superior mesenteric artery as in the lower, longer, multiple-branched, tortuous, anastomosing ileal vessels. In view of these physical differences in distribution, such a difference in pressure between the two arteries is theoretically predictable.

Several other reports on mesenteric ligation are here included for the sake of completion as well as their possible bearing on the problem at hand. Bost,¹⁰⁰ on the basis of a few clinical and experimental observations, felt that survival might ensue without resection in mesenteric tears of more than 2 inches (5 cm) if the mesentery were repaired.

98 Joffe, I. L. Surgical Anatomy of the Arterial Blood Supply to the Small and Large Intestines, *Vestnik khir* 58 38, 1939. Callander.¹ McGregor.⁵⁵ Steward and Rankin.⁸²

99 Morton, J. J. The Differences Between High and Low Intestinal Obstruction in the Dog, *Arch Surg* 18 1119 (April) 1929.

100 Bost, I. C. Mesenteric Injuries and Intestinal Viability, *Ann Surg* 89 218, 1929.

and the omentum tacked about the damaged loop Rothschild¹⁰¹ reported variable results, with several dogs dying of gangrene of an intestinal loop when several inches of the mesenteric attachment were severed while others survived. A possible explanation is that collateral circulation via a marginal artery was better developed in these animals. That such variation exists has been proved. In fact, Noer⁹⁵ pointed out that as far as small intestinal circulation is concerned the differences between dogs and human beings are so great as to cast serious doubt on the justification for the transfer of many results from one species to the other. Thus the lack of mesenteric fat, the short, intercommunicating vasa recta and the less varying simpler arcuate pattern at various levels are significant distinctions, indicating a greater circulatory reserve in dogs against gangrene in the ligations of experimental intestinal operation. Wilkie⁹⁸ found in dogs that omentum-wrapped intestine remained intact over segments 3.5 cm long with blood supply ligated but that fatal necrosis occurred in segments of greater lengths. Laufman¹⁰² reported that with heparin dogs may survive ligation of the blood supply of 10 to 12 cm of intestine, but he failed to state whether mesentery had actually been stripped for this distance from the bowel. As a matter of interest, Sarnoff and Fine¹⁰³ reported survival of dogs with the use of protective sulfonamide therapy when only the veins of a 50 cm long loop of intestine were ligated whereas all controls died.

SUMMARY AND CONCLUSIONS

The major arterial circulation of the duodenum and the gross configuration and minute end artery character of its vasa recta are described as present in 62 bodies dissected. The problem of post-gastrectomy stump leakage is discussed and methods of closure reviewed in detail. The possible etiologic significance of ischemic necrosis in dehiscence of the duodenal stump is presented. The incidence of such devascularization in the course of surgical separation of the duodenum from the head of the pancreas is emphasized in its relationship to the several anatomic patterns of distribution of the terminal branches of the pancreaticoduodenal arterial arches. The necessity for inversion of freed duodenum to the point of pancreatic attachment in cases in which

101 Rothschild, N. S. Safety Factors in Mesenteric Ligations, *Ann Surg* **89** 878, 1929

102 Laufman, H. The Effect of Heparin on the Behavior of Infarction of the Intestine, *Surg, Gynec & Obst* **74** 479, 1942

103 Sarnoff, S. J., and Fine, J. Effect of Chemotherapy on the Ileum Subjected to Vascular Injury, *Ann Surg* **121** 74, 1945

nondivulsed rami duodenales provide an intact intestinal circulation is suggested

The arterial and venous blood supply of the pancreas is depicted briefly and the arterial sources and venous drainage of the common bile duct reviewed. The anatomic impracticability of surgical ligation in bleeding duodenal ulcer is discussed, and the possible role of inadvertent surgical devascularization of a segment of common duct in injury of the ductus choledochus or failure of duct anastomoses is considered.

TOTAL GASTRECTOMY

Report of Six Cases

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IN the last few years, removal of the entire stomach has been accomplished with sufficient frequency and success to establish it as a sound procedure in certain cases of neoplastic infiltration of a major part of the stomach. In 1938, Lahey¹ reported 8 cases with 3 deaths. By 1944 Lahey and Marshall² were able to report 73 cases, the largest series on record, with an operative mortality of 33 per cent. In 1943 Pack³ reviewed 278 cases of total gastrectomy for carcinoma and added 20 cases from the Memorial Hospital for the Treatment of Cancer and Allied Diseases. The operative mortality for the entire group was 37.6 per cent, for the cases from the Memorial Hospital it was 30 per cent.

DeAmesti⁴ called attention to the fact that complete removal of the stomach may be followed by a fairly healthy existence. The reservoir function of the stomach is taken over by the jejunum. Digestion of carbohydrates, fats and proteins is not seriously affected. The antianemic factor produced in the stomach is also produced in the duodenum, and unless there is an impending deficiency loss of the stomach does not result in serious anemia. It has been found clinically that when anemia develops postoperatively it is attributable in most cases to a recurrence of carcinoma.

The following is the technic for total gastrectomy as employed in these cases.

PREOPERATIVE PREPARATION

Adequate preoperation preparation is considered essential. This includes a high protein diet, with liberal quantities of eggs, milk,

From the Veterans Administration Hospital, New York.

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1 Lahey, F. H. Surg, Gynec. & Obst. **67** 213-233 (Aug) 1938

2 Lahey, F. H., and Marshall, S. F. Ann Surg **119** 300-320 (March) 1944

3 Pack, G. T., and McNeer, G. Surg, Gynec. & Obst. **77** 265-299 (Oct) 1943

4 DeAmesti, F. Ann Surg **117** 183-190 (Feb) 1943

concentrated broth, custards and meat, this diet is usually well tolerated. Two hundred grams of protein have been given daily. This diet is supplemented with multiple vitamins and transfusions of whole blood when indicated. Gastric aspirations and lavages are employed in the presence of obstruction. Dilute hydrochloric acid is administered when there is achlorhydria. An attempt is made to improve the hygienic condition of the teeth and gums when indicated.

ANESTHESIA

Technically, the operation is facilitated by spinal anesthesia. Nupercaine hydrochloride is satisfactory, but our preference is for continuous procaine hydrochloride or tetracaine hydrochloride, supplemented continuously with pentothal sodium administered intravenously and by inhalation of oxygen. Fluids and blood are given intravenously throughout the operation.

OPERATIVE TECHNIC

Total gastrectomy is usually performed through an abdominal incision. This approach permits adequate exposure and probably involves less risk to the patient than does operation by the transthoracic route. However, if the lower part of the esophagus is involved, the transthoracic approach may be indicated.⁵ The operative technic employed in our cases is similar to that described by Allen,⁶ Lahey and Morton.⁷ The abdomen is explored through a left upper rectus incision. Total gastrectomy is indicated if no metastases are found beyond nodes which can be removed and if the tumor involves all or most of the stomach. Adjacent structures involved by direct extension may be resectable and need not necessarily contraindicate resection. The duodenum is divided and closed after the blood vessels supplying stomach and omentum have been ligated. The coronary ligament of the left lobe of the liver is divided and the liver mobilized medially. With traction on the stomach, the esophagus is mobilized digitally from the surrounding tissues, being exposed for 4 to 5 cm. The jejunum may be brought anteriorly or posteriorly to the transverse colon and sutured to the crura of the diaphragm, behind the esophagus, with interrupted silk sutures. A second row of sutures is placed between the jejunum and the esophagus. A Levine tube passed through the nose extends to the lower part of the esophagus. Suction removes secretions. After an incision has been made halfway around the esophagus and an incision of similar size has been made in the jejunum, a third mucosal

5 Meyer, H. W. *Ann. Surg.* **12** 115-127 (July) 1942. Pack and McNeer.³
Sweet, H. R. *Ann. Surg.* **118** 816-837 (Nov.) 1943.

6 Allen, A. W. *Am. J. Surg.* **40** 35-41 (April) 1938.

7 Morton, C. B. *Surg., Gynec. & Obst.* **75** 369-373 (Sept.) 1942.

row of interrupted silk sutures is placed. The esophagus is then completely divided and the anastomosis completed anteriorly, again with two rows of interrupted silk sutures between the esophagus and the jejunum and additional sutures between the jejunum and the diaphragm. Jejunojejunostomy was performed in 3 cases and is now recommended in all cases. Contamination from the esophagus must be avoided. If a retrocolic anastomosis has been used, sutures are placed between the two limbs of the jejunum and the transverse mesocolon. Sulfathiazole is placed in the upper part of the abdomen. The left lobe of the liver is replaced and the abdomen closed, without drainage. Supportive measures adequate to maintain the patient in good condition throughout the operation should be provided.

POSTOPERATIVE TREATMENT

The Trendelenburg position is maintained postoperatively for two or three days to relieve tension on the anastomosis and to promote drainage upward from the esophagus. Oxygen, if needed, may be given through a nasal tube. Fluids are given intravenously. Plasma and blood are given when indicated. Suction is continued on the Levin tube, which extends to a point just above the anastomosis. Removing secretions which may accumulate above the anastomosis prevents stress on the suture line. The tube is kept free of mucous plugs by careful irrigation twice daily with small quantities of water. Before the tube is removed, on the third or fourth day, the suction is discontinued and a small amount of water is permitted to run in by gravity. By lowering the tube any fluid which has not passed through the anastomosis is siphoned off. An adequate stoma is, in this way, determined to be present before the tube is permanently removed and the patient is permitted to take slowly increasing quantities of water, broth, milk and egg nog. This can be increased to a selected soft diet in about ten or twelve days.

REPORT OF CASES

A brief report of 6 cases in which total gastrectomy has been performed follows.

CASE 1—L. A. M., a white man aged 51, had gastric hemorrhages in 1936. There had been epigastric pain, vomiting and a loss of 20 pounds (9.1 Kg.) since May 1942. An exploratory operation was performed elsewhere in August 1942, and the patient was considered to have inoperable carcinoma of the stomach. Roentgenograms confirmed the presence of extensive growth. Reexploration was performed on Dec. 10, 1942. With the patient under nupercaine hydrochloride spinal anesthesia, a left rectus incision was made. The entire stomach was involved, there were no metastases. A total gastrectomy was performed. A retrocolic anastomosis was made with two rows of interrupted silk sutures plus sutures to the diaphragm. No jejunojejunostomy was performed. Ten grams of sulfamyl-

amide was administered. There was no drainage. Fluids plus 500 cc of blood were given by intravenous injection during the operation. The pathologic report was diffuse adenocarcinoma, grade III. Pneumonitis, which occurred postoperatively, responded to sulfadiazine. The recovery was otherwise uneventful. Roentgenograms on Jan 28, 1943 revealed an adequate stoma between the esophagus and the jejunum. The patient was reported to be well two years later. He died May 9, 1945, in another hospital. An autopsy was not performed. The clinical diagnosis was intra-abdominal carcinomatosis.

Comment—Although exploration was performed elsewhere previously and the growth was considered inoperable, reexploration revealed it to be resectable. The retrocolic anastomosis, without jejunojejunostomy, functioned well. The condition of the patient remained good for two years, but he died after two years and five months, with intra-abdominal recurrence of the carcinoma.

CASE 2—A R M, a white man aged 53, had epigastric distress, nausea and vomiting beginning in July 1943. He had a 20 pound (9.1 Kg) loss of weight. A roentgenogram showed carcinoma of the stomach. Gastric analysis showed no free acid, 10 units of total acidity and a positive reaction for blood. The patient was operated on Oct 2, 1943, under general anesthesia. The growth extended to within 1 cm of the esophagus, but there were no metastases. Total gastrectomy was performed, and a retrocolic anastomosis was made 20 cm below the duodenal-jejunal ligament. No jejunojejunostomy was performed. The transverse mesocolon was sutured obliquely about the two limbs of the jejunum. The patient was given 5 Gm of sulfathiazole, and the abdomen was closed in layers, without drainage, with interrupted cotton sutures. Administration of 500 cc of blood and fluids maintained him in excellent condition throughout the operation. The pathologic report was adenocarcinoma, grade IV. The recovery was uneventful. A roentgenogram taken Nov 8, 1943 showed adequate stoma between the esophagus and the jejunum.

The patient was readmitted on Sept 10, 1944, with a 4 cm tumor at the level of the right sixth rib. Aspiration biopsy revealed adenocarcinoma. There were no symptoms or roentgenologic evidence of local recurrence. Later, neurologic evidence or metastases to the brain developed, and the patient died on Oct. 23, 1944. Consent for autopsy could not be obtained.

Comment—This patient made an uneventful recovery following total gastrectomy. The retrocolic anastomosis, without jejunojejunostomy, functioned well. Distant metastases, without local recurrence, caused death one year later.

CASE 3—C B, a white man aged 50, had low substernal pain, epigastric fullness and a 10 pound (4.5 Kg) loss of weight in two years. A roentgenogram showed extensive carcinoma of the pars media of the stomach (fig 1A). Operation was performed on May 25, 1944, with the patient under general anesthesia. A left rectus incision was made. Carcinoma was found involving the distal two thirds of the stomach, with two serosal implants in the cardia, a 1 cm node adjacent to the esophagus and a 2 cm nodule in the spleen. The incision extended transversely. The entire stomach, spleen and tail of the pancreas were removed. The short mesentery of the jejunum required retrocolic anastomosis to the esophagus. Two rows of interrupted silk sutures plus sutures between the jejunum and

diaphragm were used. Jejunojejunostomy was performed below the transverse mesocolon. The patient was given 5 Gm of sulfathiazole and 5 Gm of sulfanilamide. The abdomen was closed, without drainage, with interrupted cotton sutures. Fluids and 500 cc of blood were given the patient by intravenous injections during the operation. The pathologic report was adenocarcinoma of the stomach and infarction of the spleen, the nodes were not metastatic. The postoperative course was smooth for ten days, then right parotitis and bilateral pneumonitis developed. The administration of sulfadiazine was ineffective. After administration of penicillin, the patient showed improvement. Pleural effusion was aspirated. Recovery followed. A roentgenogram on July 12, 1944 showed adequate stoma between the esophagus and the jejunum (fig 1 *B*). In October 1945 the blood count was normal. The patient had gained 25 pounds (11.3 Kg) and had no difficulty in eating.

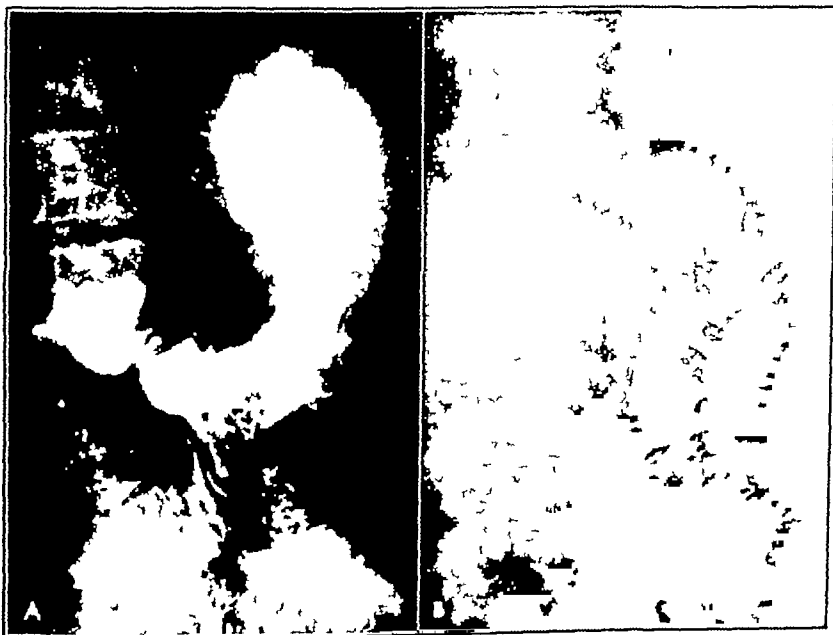


Fig 1 (case 3)—*A*, preoperative (May 18, 1944) roentgenogram, *B*, postoperative (July 12, 1944) roentgenogram, showing an adequate esophagojejunal stoma.

Comment—After a smooth early postoperative course, serious complications developed which delayed recovery. The retrocolic anastomosis, with jejunojejunostomy, functioned well. The patient was clinically well and was working seventeen months after the operation.

CASE 4—H. A. S., a white man aged 50, had epigastric pain, vomiting and a loss of 27 pounds (12.2 Kg) since March 1944. A roentgenogram disclosed a filling defect of the pars media and cardia of the stomach (fig 2 *A*). Fractional analysis showed no free hydrochloric acid and a total acidity of 10 units. On Oct 13, 1944, with the patient under continuous spinal anesthesia induced by procaine hydrochloride, a left rectus incision was made and a carcinoma was found involving the proximal two thirds of the stomach. Several slightly enlarged firm nodes were present along both curvatures. There were no distant metastases.

Total gastrectomy was performed. The jejunum was brought anterior to the transverse colon. No enteroenterostomy was performed. Five grams of sulfathiazole was left in the abdomen, which was closed with interrupted cotton sutures, without drainage. Postoperatively, the Trendelenburg position was maintained for three days. Then sips of water and broth were allowed. Recovery was uneventful except for the complaint of an "uneasy feeling" in the left upper quadrant of the abdomen after the patient had taken liquids, especially when he lay on his left side. Lying on his right side gave relief. When the patient took solid food, this feeling was prevented. After seven weeks this disappeared. The patient became asymptomatic and rapidly gained weight. A roentgenogram taken Nov 3, 1944 revealed an adequate esophagojejunal stoma (fig 2B). The patient was well in November 1945. The pathologic report was adenocarcinoma, grade II, nodes clear.



Fig 2 (case 4)—A, preoperative (Oct 6, 1944) roentgenogram, B, postoperative (Nov 3, 1944) roentgenogram, showing an adequate esophagojejunal stoma.

Comment—The postoperative course was smooth except for symptoms that occurred soon after operation that were believed to be attributable to an accumulation of fluids in the proximal jejunal loop. These symptoms subsided after seven weeks. The anastomosis was antecolic. Jejunojunostomy probably would have prevented these symptoms.

CASE 5—F M, a white man aged 53, had epigastric distress, vomiting and loss of weight, becoming progressively worse, since April 1944. He appeared chronically ill and emaciated. There were epigastric tenderness but no masses and no lymphadenopathy. A roentgenogram revealed an ulcerated lesion of the stomach. The red blood cell count was 3,800,000. On Sept 19, 1945, with the patient under continuous spinal anesthesia, total gastrectomy was performed.

The neoplasm involved the entire stomach, but there were no distant metastases. A retrocolic anastomosis was employed, with jejunojejunostomy. The pathologic report was reticulum cell sarcoma. The postoperative course was uneventful.

Comment—Total gastrectomy was performed in this case for reticulum cell sarcoma. The retrocolic anastomosis, with jejunojejunostomy, functioned well. The patient's postoperative course was uncomplicated, and improvement was rapid.

CASE 6—L. E. K., a white man aged 47, had diarrhea and a loss of 30 pounds (13.6 Kg.) since April 1945. Roentgenograms revealed a carcinoma on the lesser curvature and posterior wall of the midportion of the stomach. This was confirmed by gastroscopic examination. Fractional analysis revealed absence of free hydrochloric acid and 5 to 8 units of total acidity. The other laboratory data were noncontributory. On Nov. 15, 1945, with the patient under continuous spinal anesthesia induced by tetracaine hydrochloride, a left rectus incision was made and a carcinoma was found involving the midportion of the stomach, extending proximally to within 2.5 cm. of the esophagus. Slightly enlarged nodes were present along both curvatures, but these were not definitely metastatic. No distant metastases were found. Total gastrectomy was performed, with a retrocolic anastomosis and with a jejunojejunostomy below the transverse mesocolon. The pathologic report was adenocarcinoma. The postoperative course was uneventful.

Comment—Following total gastrectomy, a retrocolic anastomosis was formed, with jejunojejunostomy, below the transverse mesocolon. The postoperative course was entirely uneventful.

CONCLUSIONS

1. No patient with carcinoma of the stomach, no matter how extensive it is or what part of the stomach is involved, should be denied exploration unless metastases can be demonstrated or unless his condition is too poor to withstand operation.

2. Total gastrectomy has been recently performed with increasing frequency and success and has been established as a sound procedure. Expert administration of anesthesia and adequate supportive treatment are essential.

3. Total gastrectomy may be followed by fairly good health and need not prevent gainful employment.

SUMMARY

Six consecutive cases of total gastrectomy for neoplasms of the stomach are reported, with no operative death.

The first patient died of recurrence after two years and five months. The second died after one year of distant metastases with no evidence of local recurrence. The third patient has been well for eighteen months and the fourth for thirteen months. The fifth was operated on two months before and the sixth within the month before this article was written.

NONADHERENT SURGICAL DRESSINGS

MAJOR ROBERT BINGHAM

MEDICAL CORPS, ARMY OF THE UNITED STATES

THE tendency for surgical dressings to adhere to raw surfaces of wounds has probably plagued both surgeons and patients since the dawn of civilization. From the rare and costly ointments of ancient times to the refined petroleum products of today, various expedients have been tried to prevent dressings from adhering to damaged body tissues. Recent technics have been making more and more use of synthetic fabrics which are nonadherent by virtue of the waterproof qualities inherent in their manufacture. But almost all the new substances proposed have a disadvantage in common in that they cause some obstruction to the free drainage of blood, serum, pus or debris of necrotic tissue from the depths and surfaces of the wound. The damming back of these waste products frequently results in delayed healing, irritation and excoriation of the surrounding skin and at times extension of infection.

The evolution of improved technics in military surgical procedures which have been developed in United States Army hospitals overseas during this war demands new and superior dressing materials. In less than five years, the routine treatment of compound fractures by the local application of sulfanilamide to the wound followed by light packing with gauze impregnated with petrolatum jelly, the so-called petrolatum gauze, and a plaster of paris cast has been almost entirely abandoned. As life saving as the Orr-Trueta treatment proved to be, it always had the drawbacks of foul-smelling casts and prolonged healing of wounds, and it required late skin grafting in many cases. Now, with advent of penicillin therapy, early definitive surgical treatment can be safely undertaken in over 90 per cent of these cases. Complete and thorough debridement can usually be followed by secondary closure of the wound or split thickness skin grafting in from three to ten days after injury. The resulting convalescent period is greatly shortened and the rehabilitation of the soldier-patient facilitated.

Soft tissue wounds and severe burns have been successfully treated by similar methods. Following debridement the lesion is protected by pressure dressings. Penicillin is administered prophylactically or to control infection, as most wounds in the surgical treatment of battle casualties either are contaminated or show localized infection. Early secondary closure or skin grafting is the rule, and a higher percentage

of earlier recoveries has resulted than by the allowing of the wound to heal by secondary intention and scar tissue

The exigencies of evacuation and transportation of the wounded often required that dressings and casts be maintained for many days or even weeks without changing. These factors all demand a wound covering which is nonadherent, permits free drainage of exudates and gives support and protection to healing tissues after surgical treatment of the injury. Petrolatum gauze, the material most commonly used in cases referred to our hospitals, fails to meet these requirements, and in the heat and high humidity of the tropics it often acts as a moisture-entrapping foreign body in the wound.

NONADHERENT DRESSINGS

Recent articles in the surgical literature have described various substitutes for petrolatum-impregnated gauze. Potts, in a report from this hospital, has well summarized the case against this type of dressing.¹ He has stated

The use of petrolatum gauze to cover granulating wounds is objectionable for several reasons. (1) From such wounds the purulent drainage is discharged around the petrolatum gauze pack and comes in contact with normal skin. The petrolatum keeps the skin about the edge of the wound soft and makes it susceptible to irritation from the constant flow of purulent drainage. This leads to maceration and frequently to the development of small superficial furuncles. (2) Granulation tissue piles up beneath an impervious dressing, especially in areas where it is difficult to maintain adequate pressure on the wound. (3) Even though a number of layers of petrolatum gauze are laid over a granulating wound, the petrolatum from the gauze tends to liquefy and soak into the dry dressings above. Consequently, when dressings are changed, it is found that the petrolatum gauze has become rather firmly adherent to the granulation tissue. In spite of utmost gentleness in its removal, extensive capillary bleeding is started.

To overcome these difficulties, Potts has devised a simple dressing made of mosquito netting impregnated with a mixture of 75 per cent paraffin and 25 per cent petrolatum jelly. This he has named "paraline gauze." We have used this preparation under his supervision successfully in many cases and find it excellent as an improvised nonadherent dressing that can be made by any surgical department. Its chief disadvantages lie in the care and labor entailed in its preparation. A degree of skill and experience is necessary to assure uniformity in the amount of mixture retained in the netting, sterilization technic must be flawless, since paraline gauze cannot be autoclaved, and special wrappings or containers are required for storage until it is used. These qualities render it unsuitable for mass production or field service.

Cellophane covers from individual cigaret packages have been suitably perforated and used as transparent wrapping material for open

¹ Potts, W. J. A Simple Dressing for Granulating Wounds, *Bull. U. S. Army M. Dept.*, May 1945, no. 88, pp. 46-47.

wounds and ulcers and, according to Ellis, have proved economical and satisfactory.² Twyman, at a United States Army installation in the European Theater of Operations, used waxed paper from the outside of cigaret cartons, washed, sterilized and punched with holes at $\frac{1}{4}$ inch (64 cm) intervals, to make basic coverings for wounds.³ Foman's surgical textbook has reviewed the use of other materials wide-meshed gauze impregnated with petrolatum, paraffin or bismuth tribromphenate ointment, tulle grass, perforated cellophane and rubber tissue and silver foil.⁴ In all these substances, the problem of sizes and suitable spacing of perforations to permit sufficient drainage of wounds is the chief drawback to their adoption.

The treatment of burns has been advanced by the use of synthetic fabrics. Owens now applies a fine woven "rayon B" cloth as the basic layer for his pressure-dressing technic.⁵ This material, being smooth and sheer, has a low coefficient of friction and will not adhere to wounds and raw burned skin. "Fiberglas" cloth, a glossy fabric woven from threads made of filaments of fine spun glass, has been successfully applied as the first layer in the treatment of burns by Hirschfeld and his associates.⁶ Through the courtesy of the manufacturers,⁷ my colleagues and I have tested a quantity of each of these materials and have verified these clinical results. However, the extremely tight mesh of these fabrics will not permit the drainage of exudates except by absorption. Both fabrics absorb blood serum by their high capillary attraction and filtering action, but they obstruct pus and discharges from necrotic tissue. This quality makes them less suitable for wounds than for first and second degree burns.

CRITERIA FOR A NONADHERENT DRESSING

To meet all possible practical requirements for both civilian and military surgical uses, a group of surgeons in two United States Army hospitals in the Pacific Theater of Operations have agreed that a

2 Ellis, M. Transparent Wrapping Material for Dressing Open Wounds and Ulcers, *Brit M J* **1** 697 (June 5) 1943.

3 Twyman, R. A. Use of Wax Paper as a Surgical Dressing, *Bull U S Army M Dept*, November 1944, no. 82, p. 34.

4 Foman, S. The Surgery of Injury and Plastic Repair, Baltimore, William Wood & Company, 1942, p. 125.

5 Owens, N. Use of Pressure Dressings in the Treatment of Burns and Other Wounds, *S Clin North America* **23** 1354-1366 (Oct.) 1943, Use of Rayon Surgical Fabric, personal communication to the author, Nov. 8, 1944.

6 Hirschfeld, J. W., Williams, H. H., Abbott, W. E., Heller, C. G., and Pilling, M. A. Significance of the Nitrogen Loss in Exudate from Surface Burns, *Surgery* **15** 766-775 (May) 1944.

7 Rayon B, "Winchester Medical Fabric," was furnished by Winchester Mills, Inc., 120 West 42nd St., New York, and Fiberglas cloth was furnished by Owens-Corning Fiberglas Corporation, Toledo, Ohio.

nonadherent basic dressing material for wounds should fulfil the following criteria

1 It should be a fabric of sufficiently wide-open mesh to permit the free escape of blood, serum, pus and tissue exudates from the depths and surfaces of the wound without obstruction (By microscopic measurement, the openings in the material should measure about 0.4 to 1 mm in diameter)

2 The fabric should have sufficiently fine mesh to be smooth, to have a low coefficient of friction and to prevent adherence to surfaces of wounds by growth of capillary loops of granulation tissue, fibrous tissue and newly formed epithelial cells (The width of the mesh previously given fulfils these requirements. If the strands are from 0.2 to 0.3 mm in diameter, the resulting fabric has 20 or 32 threads per inch [2.5 cm] in each direction and is known as "mesh 20" or "mesh 32" respectively)

3 The fibers should be of a waterproof substance or a thread that has been treated to make it nonabsorbent and water resistant. This gives a firm, glossy texture, or hand, to the fabric and prevents it from adhering to the wound by absorption and clotting of blood and serum in its fibers. This quality can be imparted to the cloth by several finishing processes⁸

4 The chemical nature of the basic material and all finishing substances should make it neutral and nontoxic to human tissues, cells and body fluids and unaffected by bacterial action

5 It should be resistant or chemically inert in the usual surgical solutions—isotonic solution of sodium chloride, alcohol, ether, benzene, iodine and mercurial antiseptics

6 It must be readily sterilized by boiling, autoclaving, dry heat and immersion in antiseptic solutions

7 It should be a fabric that can be manufactured and processed in large quantities, cut to any size or shape by ordinary scissors and compactly packaged, and it must be resistant to heat, dampness, mildew and deterioration by exposure to sunlight and air during storage and use

8 It should be soft, flexible, light in weight and relatively low in cost

In this paper we wish to add to civilian surgical literature the description of one type of nonadherent dressing material that has satisfactorily passed all clinical and laboratory tests during the past year in two United States Army hospitals. It has been called by us "nylon surgical gauze." In view of the experimental status of the determination of the fiber, weight and mesh best suited to surgical

⁸ The Case for Synthetic Textiles, editorial Modern Plastics (Overseas Ed)
23 3-9 and 78-81 (March) 1945

requirements the Medical Department of the United States Army has not yet made nylon surgical gauze a standard item of issue

DEVELOPMENT OF NYLON SURGICAL GAUZE

During the summer of 1944 a shipment of "Screening, Insect, Plastic Nylon" was received by a United States Army hospital in the Russells British Solomon Islands. This was intended to be used as a substitute for copper insect screening and was developed according to specifications of the United States Army Engineers. Its fine mesh, smooth glossy finish and nylon composition immediately suggested itself to us as a nonadherent dressing material. We had already used nylon in sutures for orthopedic operations and found it extremely well tolerated by body tissues.

Sections of the screening measuring 4 by 4 inches (10 by 10 cm) and 4 by 8 inches (10 by 20 cm) were cut and washed, sterilized in



Fig 1—Nylon plastic insect screening (olive drab color) used as a new type of nonadherent dressing over the site of a skin graft

the autoclave with our other dressings and used in the operating rooms and on the wards in the treatment of battle casualties. A total of 200 patients have been treated and observed. There was a notable absence of irritation and maceration of the skin, the wounds were cleaner and drier than with the petrolatum gauze previously used, drainage was rapidly absorbed into the absorbent gauze placed on top of the screening and healing of the wound appeared accelerated (fig 1). In spite of apprehension on the part of some of the staff, in no case did the material adhere to the granulation tissue of the surface of the wounds. Both surgeons and patients were pleased at the ease and freedom from pain with which dressings could be changed. The screen being flat and having a certain amount of stiffness, the granulation tissue in irregular wound cavities would grow out to the screen and then spread out, forming a smooth, level surface, ideal for the placement of skin grafts. Freedom from surface bleeding caused by changes of dressings was

remarkable and allowed a saving in the amount of sponges and pads necessary to complete the toilet of a wound. There were no cases of cutaneous sensitivity or irritation which could be attributed to the nylon screen.⁹ This suggested our undertaking further studies to perfect this material for surgical use. The original nylon material was of olive drab color and had a certain amount of stiffening applied for screening purposes.

Samples were sent to the United States to the laboratory service of a United States Army general hospital, where Queen made microscopic examinations and measurements.¹⁰ He reported that the strands measured 0.3 mm in diameter and the holes of the mesh measured just under 1 mm in diameter. Since the capillaries of granulation tissue measure from 5 to 50 microns in diameter and are approximately four times their own diameters apart, it is difficult for buds of granulation tissue to grow through a mesh this fine.

With the data at hand, we requested two manufacturers of nylon fabrics to furnish us with undyed cloth for use as "nylon surgical gauze."¹¹ The fabric, as supplied by these companies, is a soft, smooth, opalescent white, glossy cloth, with a fine-meshed weave of strands of pure, twisted nylon thread, finished to make it water repellent.

Nylon is a polyamide plastic resin which can be spun into a smooth, bright thread resembling silk, but stronger in tensile strength. It is slightly elastic, water resistant, inert in body fluids, immune to bacterial action and not affected by ordinary surgical solutions— isotonic solution of sodium chloride, alcohol, ether, benzene, iodine and the mercurial antiseptics. It can be sterilized by any method, since it tolerates temperatures up to 450 F before softening, and its resistance to deterioration from heat, dampness, mildew, storage, age, air and sunlight is extremely high.¹²

Nylon yarn is woven into a 34 filament, 210 denier gauze in a nonslip mesh of 20 strands to the inch (2.5 cm) (mesh 20). If a stiffened cloth is desired, a finish of nylon type 6 plastic can be added.

NEW SURGICAL DRESSING TECHNIQS

With a stable, nontoxic dressing material such as nylon surgical gauze, our dressing technics have been improved and several new modifications have been added. Other uses no doubt will be discovered by surgeons in other hospitals who have the opportunity to test this material.

⁹ Bingham, R. Nylon Surgical Gauze, *Modern Plastics*, **23** 111-112 (Dec.) 1945.

¹⁰ Queen, F. B. Personal communication to the author, Oct. 4, 1944.

¹¹ Nylon Surgical Gauze was furnished by Johnson & Johnson, New Brunswick, N. J., and by The Huguet Fabrics Corporation, Hornell, N. Y. The nylon is a product of the E. I. Du Pont de Nemours and Co., Wilmington, Del.

¹² Plastic Properties Chart, Nylon Resins (Molding), New York Plastic Catalogue Corp., 1944.

1 In compound fractures after debridement, a strip of the gauze is lightly folded into the depths of the wound and brought to the surface as a drain. Its porous mesh provides an excellent tract for the flow of wound secretions, and it does not have the tendency to pack down and block up the wound cavity as petrolatum gauze frequently does. This light packing is removed within three days or as soon as adequate drainage can be maintained without it, and a single layer of the nylon surgical gauze is then placed flat over the wound (fig 2). If possible, a secondary closure or split thickness skin graft operation and final

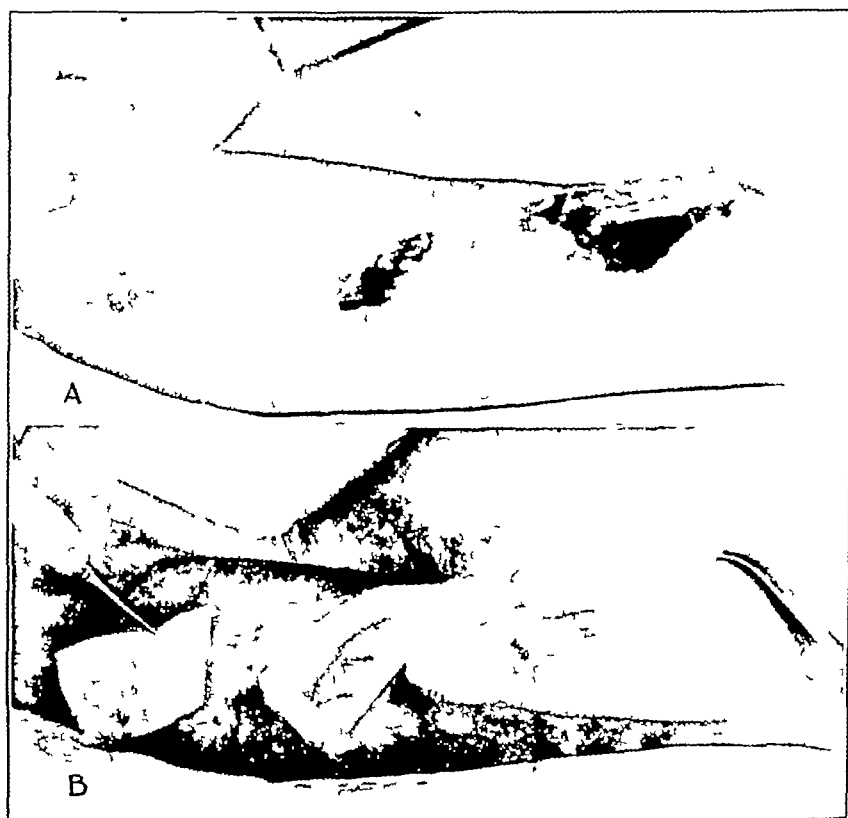


Fig 2—*A*, compound, comminuted fractures of the leg, showing penetrating wound cavities after debridement. *B*, nylon surgical gauze used as the basic layer of a nonadherent dressing for the wounds shown in figure 2 *A*.

reduction of the fracture is done within the three to ten day period after injury. Penicillin is given parenterally. Above the nylon gauze are laid several layers of absorbent cotton gauze, and a well padded and molded plaster cast is applied. If early closure cannot be done because of the extent or multiplicity of the wounds, then nylon surgical gauze is laid in a single layer over the wound cavity. Granulation tissue will grow to the surface of the gauze and spread out in a flat surface, which will be ideal for later skin grafting, when the cavity

has filled in with healed tissue. Since drainage is conducted away from the wound and absorbed into the outer coverings placed above the nylon gauze, there is noticeably less odor, less irritation to the skin and more rapid healing than with the original Orr technic.

2 Soft tissue wounds are treated similarly except that, in place of a padded plaster cast, pressure dressings of gauze fluffs, mechanics waste, cotton or cellulose-filled pads are used, covered with firm layers of elastic or semielastic bandage.

3 For burns, nylon surgical gauze may be impregnated with petrolatum jelly, sulfadiazine ointment or the surgeon's favorite bland burn medicine. Since nylon gauze is impervious to water and oils, it does not absorb ointments and dry out as does a cotton base. Wet sodium chloride or Foille dressings may be applied by the placing of nylon gauze over the burned area and then the laying of cotton gauze pads soaked and dripping with the solution on top, wrapping in cellophane or oiled silk and applying pressure dressings. If the dressings happen to dry out before they are changed, they do not become painful or adhere to the burned surface. Subsequent changes of dressing are facilitated, as the nylon gauze does not tend to traumatize the healing surface or disturb the granulation tissue and regenerating epithelium.

4 Under wet dressings for infections and ulcers, nylon surgical gauze permits free drainage of wounds and yet the dressings will not adhere if they dry out inadvertently.

5 In skin grafting, nylon surgical gauze has proved to be an ideal covering both for the raw donor site and for the recipient site to hold pinch grafts or split thickness grafts in place. The surface is kept flat by the nylon gauze, and exuberant granulations cannot grow high between the islets of epithelium.

6 Rolled to the size of a Penrose drain, a length of nylon surgical gauze provides an ideal cavity drain. Its porosity prevents blockage, and it cannot adhere to the depths or the sides of the wound.

7 For dressings which must be changed frequently because of drainage or for application of medicine, the basic nylon dressing may be left in place, sponged or irrigated for cleansing and new layers of medicament and absorbent dressings applied again.

8 In large wounds or burned surfaces it has a distinct advantage particularly in hot or humid climates, as the porosity of nylon surgical gauze allows the skin "to breathe" and normal perspiration is not hindered.

9 A narrow strip placed over a suture line prevents the sutures and the healing incision from adhering to the dressings.

10 A single layer placed over the end of a guillotine amputation stump, under slight pressure, prevents the growth of exuberant granulation tissue until traction allows growth of skin over the wound.

COMMENT

The excellent results we have had with nylon surgical gauze and plastic insect screening cloth in many types of wounds and injuries have stimulated our interest in the use of plastic and synthetic fibers in the surgical field. Early publication of this work is desired in hope that other surgeons may be able to test and improve these methods. We do not claim that the type of nylon surgical gauze which we describe is the final form in which it will be most useful. A finer mesh, a lighter strand and use of the gauze in layers—all might give satisfactory results. Nylon is not the only synthetic fiber which has these physical and chemical properties. Any cotton, linen or wool fiber can be processed by plastic or synthetic rubber finishes to make it water resistant and nonirritating. Substances such as Fiberglas, Saran and other heat-stable plastic yarns could be woven into a similar gauze. Now that shortages of material due to wartime needs for these fabrics are at an end, the possible experimental uses of these materials can be more extensively investigated.

CONCLUSIONS

1 Most nonadherent dressings for wounds and burns tend to obstruct drainage from wounds, irritate and macerate the skin and are difficult to prepare and keep in storage.

2 Modern surgical routines of penicillin therapy plus early definitive surgical procedures—secondary closure and skin grafting—require a flat, porous, stable and nonadherent dressing.

3 A fabric that is waterproof, nontoxic and nonadherent has been used with success in a large number of cases in two overseas United States Army hospitals. Called "nylon surgical gauze," it has fulfilled all criteria proposed for an ideal nonadherent dressing. It can be sterilized by any method, and it is not affected by ordinary surgical solutions.

4 Nylon surgical gauze has introduced new possibilities in the technics of dressing wounds and burns.

Many medical officers of the Army of the United States and executives of the plastics industry assisted the author in preparation of this article.

Among those not already mentioned in the footnotes and bibliography are Major Leo Grezk, Lieut. Col. Robert F. Sharer, Capt. L. R. Lonnergan, Capt. C. M. Coe, Capt. Francis M. Dwan and Lieut. Col. Harold A. Sofield, Medical Corps, Army of the United States, Mr. C. L. Hamilton, of Winchester Mills, Mr. G. W. Volckhausen, of Owens-Corning Fiberglas Co., Mr. E. E. Dickson, of Johnson & Johnson, and Mr. E. J. Celette, of Huguet Fabrics Corporation. Harriet B. Josephs, assistant publisher of *Modern Plastics* magazine, has furnished valuable reference material and read the proof.

TOTAL PANCREATECTOMY FOR CARCINOMA OF THE PANCREAS IN A DIABETIC PERSON

Metabolic Studies

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WE ARE presenting a case in which total pancreatectomy was performed for carcinoma of the pancreas developing in a diabetic patient. At the time when this paper was written, twelve months after operation, the patient was living and well. Cases of total pancreatectomy in which the patient is living and well as long as twelve months after operation are sufficiently rare to justify presentation. In fact, we know of only 1 other such case, that of Priestley, Comfort and Radcliffe,¹ in which the patient was living and well eighteen months after operation. Our case is of interest further in that the patient was diabetic before the development of carcinoma and before operation.

Our patient presented an opportunity to make certain observations on the effect of total loss of internal and external pancreatic secretions on metabolic processes. We are presenting data, incomplete as they are, on the formation of ketone bodies during insulin privation, on the loss of foodstuffs in the stool and on hepatic function as a contribution to our knowledge of depancreatized man.

From the Departments of Surgery and Medicine, Mayo Clinic

1 Priestley, J T, Comfort, M W, and Radcliffe, J, Jr. Total Pancreatectomy for Hyperinsulinism Due to an Islet-Cell Adenoma. Survival and Cure at Sixteen Months After Operation, Presentation of Metabolic Studies, *Ann Surg* **119** 211-221 (Feb) 1944

2 Brunschwig, A, Ricketts, H T, and Bigelow, R R. Total Pancreatectomy, Total Gastrectomy, Total Duodenectomy, Splenectomy, Left Adrenalectomy and Omentectomy in a Diabetic Patient. Recovery, *Surg, Gynec & Obst.* **80** 252-256 (March) 1945

REPORT OF A CASE

The patient was a white man, aged 50 years, whose history included attacks of pneumonia, typhoid fever, rheumatic fever and pleurisy. In November 1942, after a period of polyuria, polydipsia, polyphagia and loss of strength, he lost consciousness in diabetic coma and was treated with insulin. His condition improved under a regimen that included 22 units of protamine zinc insulin daily. In July 1943 he began to have chills and fever, with a temperature up to 102 F. This condition was diagnosed as malaria, and he was given a course of quinacrine hydrochloride. Jaundice and pruritus soon were noted, and the patient lost 50 pounds (22.7 Kg). His course continued to be downhill. He began to have hematemesis, and many transfusions were given. In December 1943, cholecystojejunostomy was performed by his local surgeon. The gallbladder was described as thick and edematous, the common duct was distended and the pancreas was enlarged and edematous. The fasting blood sugar ranged from 114 to 360 mg per hundred cubic centimeters, and the icterus index varied from 50 to 180. The jaundice and pruritus cleared, and the patient was well until April 1944, when he again began to have massive emesis.

On examination at the Mayo Clinic in May 1944, the patient was acutely ill and dehydrated. Gastric retention exceeded 1,000 cc. Examination of the fluid

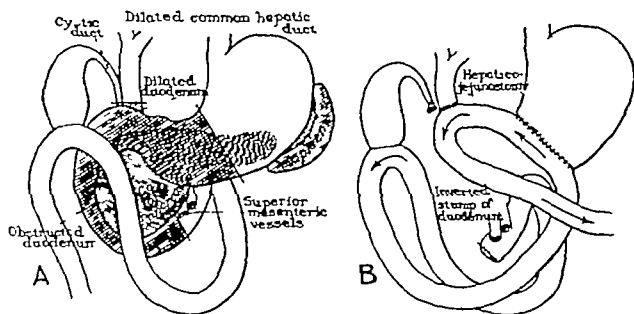


Fig 1—A, location of carcinoma of the pancreas, tissue to be resected is shaded, the broken lines represent the portion of the pancreas behind the stomach, B, arrangement after total pancreatectomy, splenectomy, partial duodenectomy, partial gastrectomy, resection of common duct, gastrojejunostomy and hepaticojejunostomy

revealed absence of free acid except on one occasion, when 20 units of free hydrochloric acid was found. At this time he was taking 24 units of protamine zinc insulin daily. Roentgenographic examination after ingestion of barium sulfate showed an obstructing lesion of the duodenum in the region of the ampulla of Vater.

After suitable preoperative preparation, celiotomy was performed on May 12, 1944. The details of the surgical findings and procedure were as follows:

Through an upper left rectus muscle-splitting incision, a large tumor of the head and body of the pancreas was identified (fig 1a). This tumor, which was obscured by edema and the surrounding reaction, was encircling and constricting the second portion of the duodenum. The tail of the pancreas was atrophic and nodular. Since examination of the abdominal viscera failed to reveal metastasis, pancreatectomy was undertaken, after the relatives had been consulted. Removal of the spleen improved the exposure, reduced the bleeding and provided an approach for dissecting the tail and body of the pancreas from its bed. The second portion of the duodenum was reflected medially, with ligation of the gastroduodenal and

the inferior pancreaticoduodenal vessels. Since at this point progress was impeded by the anastomosis made at the time of cholecystenterostomy in 1943, the gallbladder was disconnected from the jejunum. What appeared to be a dilated (2 cm) common duct was actually the cystic and the hepatic duct, closely fused to the duodenum. The right gastric and gastropiploic vessels were ligated, and

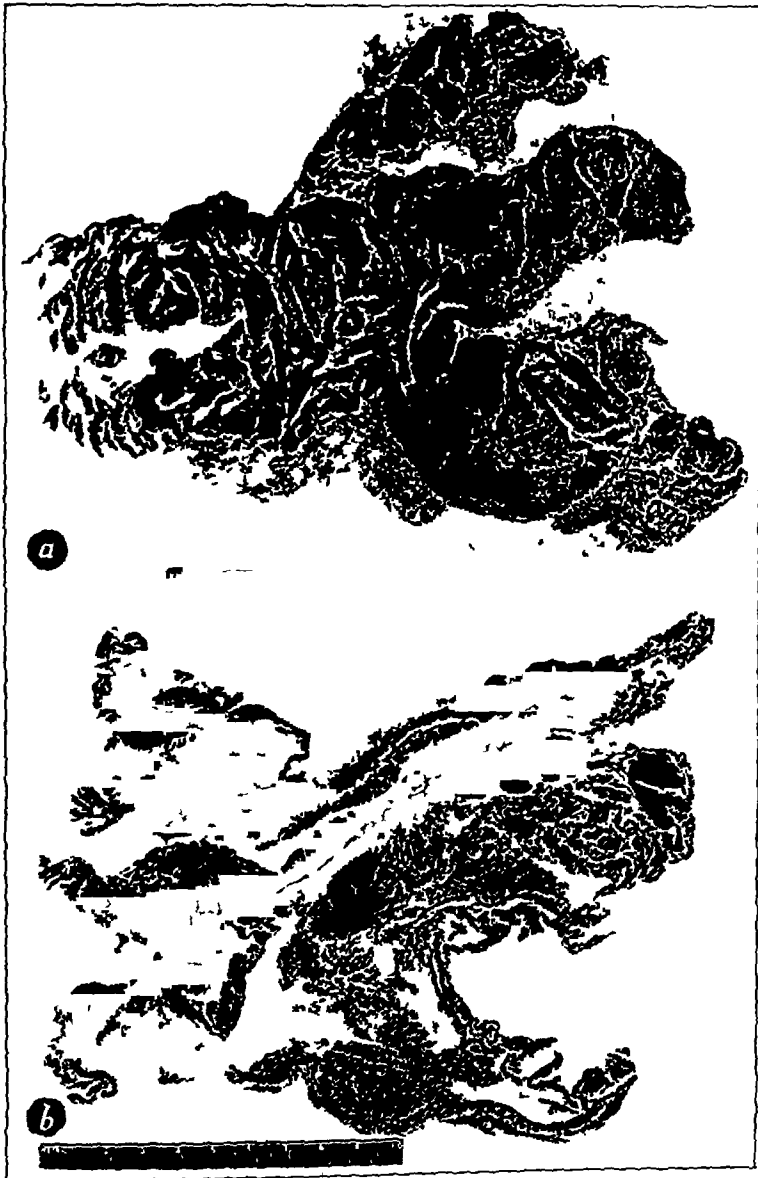


Fig. 2—Resected portion of the stomach and duodenum and the entire pancreas, *a*, anterior view and, *b*, posterior view

the distal third of the stomach was freed. Dissection over the portal vein and the superior mesenteric vessels was difficult and hazardous. The stomach was transected, and the duodenum was divided short of the ligament of Treitz. The

pancreas, duodenum and distal third of the stomach were removed (fig 1 A) The duodenal stump was inverted close to the transverse mesocolon. Anterior gastrojejunostomy (end to side) was performed, and distal to the stoma the dilated hepatic duct was implanted into the jejunum at a convenient site (fig 1 B) The extent of the resection permitted careful verification of total removal of the pancreas. After intraperitoneal distribution of 5 Gm of sulfathiazole, the abdomen was closed. Despite the length of the procedure (three hours and forty minutes), the pulse rate never was more than 100 beats per minute. Whole blood, 2,500 cc, was given intravenously during and after the procedure as a supportive measure.



Fig 3—Carcinoma of the pancreas ($\times 2$)

The pathologists reported that the specimen consisted of 10 cm of stomach, 15 cm of duodenum and the entire pancreas (fig 2). A normal spleen also was included. The tumor in the head of the pancreas was an ulcerative mucous adenocarcinoma, grade 2 (Broders' classification), that had compressed and ulcerated the duodenum (fig 3). The common duct was short, dilated and completely obstructed. The stumps of the cystic and hepatic ducts were dilated. Many peripancreatic nodes revealed lymphatic involvement. The stomach was greatly dilated but was otherwise normal.

The postoperative course was surprisingly uneventful, and the patient swung his feet out of bed on the eighth postoperative day. The highest recorded temperature was 101.4 F. On the forty-fifth postoperative day, after a spell of vomiting, roentgenologic examination revealed a normally functioning gastrojejunal stoma. The amount of insulin administered during the first thirty-five days is given in table 1. From the twenty-second to the seventy-ninth postoperative day and from the two hundred and thirtieth to the two hundred and fifty-first day detailed metabolic studies were made. The patient was ambulatory during all of this time. His cooperation was wholehearted, since he previously had been told that nothing could be done for him. Between the time of his dismissal on the seventy-ninth postoperative day, and his return, seven months after operation, for review of his condition he had regained his strength and had gone back to work. He had taken 24 enteric-coated pancreatin tablets daily and had had one large formed stool daily. His insulin requirement was filled by the administration of 40 units of protamine zinc insulin daily. Twelve months after operation the patient reported that his condition was good.

TABLE 1—Insulin Administered After Total Pancreatectomy

Days After Operation	Units of Regular Insulin Required Daily
1	20
2	52
3	52
4	20
5	52
6	40
7	44
8 to 14	20 to 40
15 to 21	30
22 to 28	16 to 36
29 to 35	32 to 36

EFFECT OF INSULIN PRIVATION ON A TOTALLY DEPANCREATIZED HUMAN BEING

An effort was made to study some of the changes in the patient's metabolism during insulin privation. Insulin was withheld during two intervals, each of eighty-nine hours' duration, in order to determine the relative tendency toward the development of ketosis. The diet from the fifty-first to the seventy-ninth day, which included the first interval of insulin privation, contained 2,940 calories, 440 Gm of carbohydrates, 100 Gm of protein and 100 Gm of fat, together with 45 pancreatin tablets daily. On the sixty-second day the use of ordinary insulin in doses of 30 units morning and evening was begun, the last dose was given at 6 p. m. on the sixty-sixth day. The administration of insulin was resumed eighty-nine hours later, thus providing a basal period before deprivation and a period of adjustment afterward.

Qualitative determinations of urinary sugar, acetone and diacetic acid were performed four times a day. Determinations of the blood

sugar, chlorides and urea were performed daily before and after insulin privation. While the patient was deprived of insulin, determinations were made three times a day to check on any abrupt change that might occur. Occasional determinations of calcium, phosphorus, cholesterol, cholesterol esters, lecithin, fatty acids, total lipids and protein with albumin-globulin ratio were performed. The respiratory quotient and corrected basal metabolic rate were recorded daily.

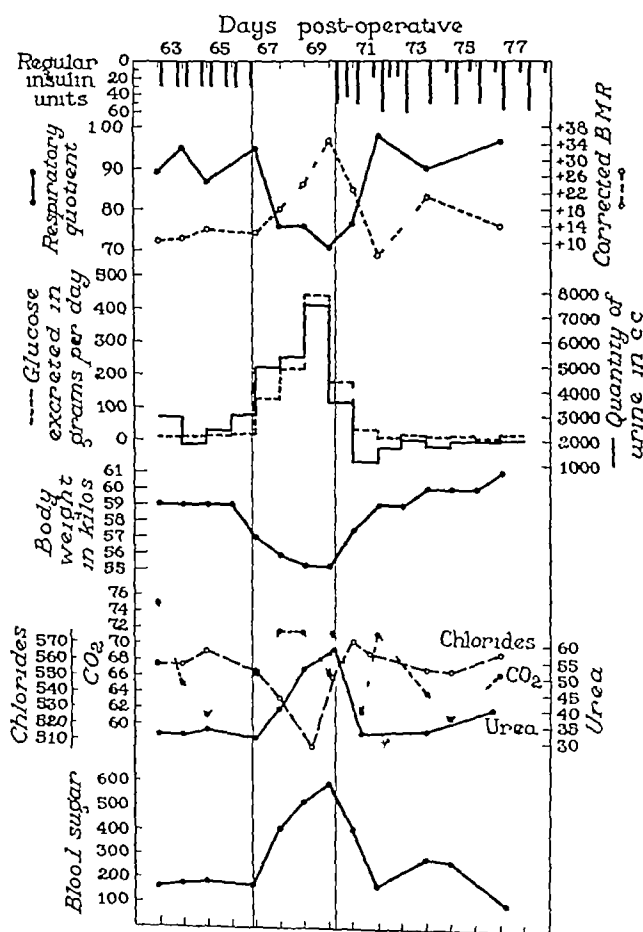


Fig 4—Laboratory data before, during and after first interval of insulin privation, which is indicated by the two vertical lines

Results of some of the determinations before, during and after the first interval, of eighty-nine hours, of lack of insulin are given in figure 4. During the basal period with insulin, the respiratory quotient ranged from 0.87 to 0.95. At the end of the period of privation it was 0.71. At this time the corrected basal metabolic rate was +37 per cent. During the last twenty-four hours of the time the patient was without insulin, he excreted 423.16 Gm of glucose in 7,450

cc of urine. He lost 3.1 kg in the eighty-nine hour period. The fasting blood sugar before insulin privation ranged from 158 to 179 mg per hundred cubic centimeters, during the period without insulin it rose to 402 to 594 mg. After ingestion of about 100 Gm of dextrose in the fifty-fifth hour of insulin deprivation, the blood sugar rose to 813 mg. At this time the patient complained of dizziness and weakness. Determination of the carbon dioxide-combining power did not show any evidence of acidosis, the value was 65.5 volumes per hundred cubic centimeters of plasma in the eighty-ninth hour. The chloride value fell to 507 mg per hundred cubic centimeters of plasma. With the low concentration of chloride, the patient complained of severe abdominal and muscular cramps. These were relieved dramatically by the administration of 3 Gm of sodium chloride by mouth. The urea rose to 57 mg per hundred cubic centimeters of blood, despite the excretion of a tremendous quantity of urine. Determinations of urinary acetone and diacetic acid gave negative results except during the last eight hours of insulin deprivation, when a faint trace of acetone was found. This faint trace persisted for twenty-four hours after administration of insulin was started, even though the qualitative sugar determination was as low as 1 plus, with 33.5 Gm of glucose excreted in twenty-four hours. During the last twenty-four hours of insulin privation, the total nitrogen excreted in the urine was 18.8 Gm. During the period with insulin, the total excretion of nitrogen was 11.3 Gm.

After intensive study, the patient was dismissed in good condition on the seventy-ninth postoperative day. During sixty-five of the seventy-nine days, he assumed normal activity. His weight was greater than it had been previous to operation.

On the two hundred and thirtieth postoperative day, the patient returned to the clinic for further metabolic studies. It will be recalled that during the first interval he had received 440 Gm of carbohydrate daily. In order to make a more critical test of the tendency toward development of ketosis after pancreatectomy, 120 Gm of carbohydrate, 100 Gm of protein and 135 Gm of fat were given for four days previous to and during the second interval of insulin privation. On the second day of the second interval of privation, the patient excreted as much as 164 Gm of glucose. The resulting depletion of hepatic glycogen would provide conditions more favorable for the development of ketosis than existed in the first interval of privation. Furthermore, an attempt was made in the second interval to compensate for the great loss of salt by oral administration of 750 cc of a salt mixture daily. This provided 7.5 Gm of sodium chloride and 3.75 Gm of sodium citrate daily before, during and after privation. It was hoped

that this would diminish the severe weakness and abdominal cramps, which were the only complaints of the patient during the first interval

Determinations were made of the daily urinary excretion of glucose, total nitrogen, betahydroxybutyric acid, chlorides, sodium and potassium. Specimens of blood were analyzed daily for carbon dioxide content, betahydroxybutyric acid, sodium, potassium and glucose. Hematocrit readings did not show significant changes, roughly ruling out mass shifts due to hemoconcentration. Except for these alterations that is, reduction of carbohydrate intake, addition of salt solution and

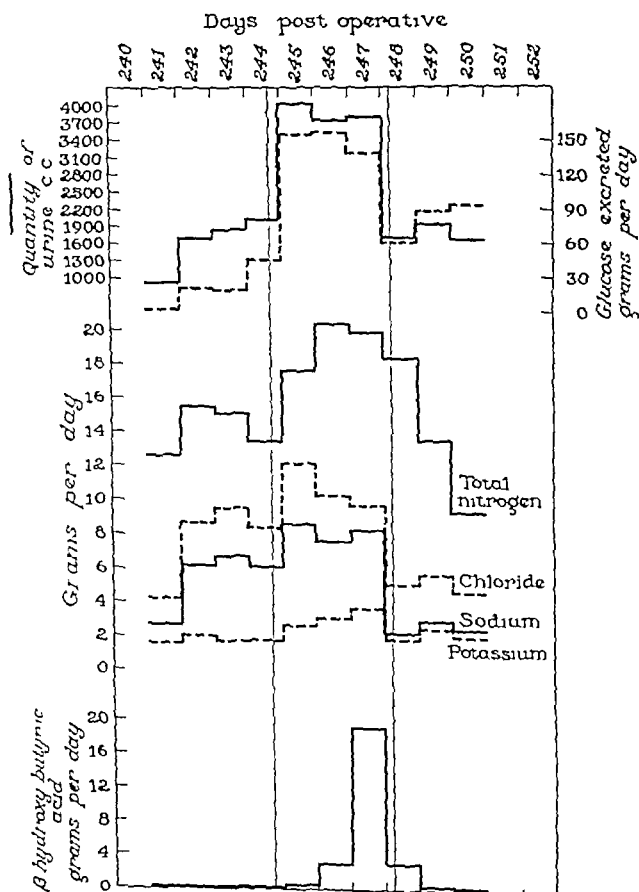


Fig 5—Substances excreted in the urine during second interval of insulin privation (indicated by two vertical lines)

more extensive urinary and blood determinations, the second interval of deprivation of insulin was similar to the first. In both intervals, insulin was withheld for eighty-nine hours.

The results of the various studies in the second interval are shown in figures 5 and 6. The patient lost 3.6 Kg of body weight. On the last day of privation, loss of appetite limited his intake to 1,374 calories (82 Gm of carbohydrate). His maximal water intake, which occurred

on the second day of insulin privation, was 5,100 cc. For the three days the urine showed a + plus reduction. During the last twenty-four hours the result of the test for acetone and diacetic acid in the urine was 1 plus, this amounted quantitatively to a urinary excretion of 19.1 Gm (184 milliequivalents) of betahydroxybutyric acid. During these twenty-four hours, the concentration of betahydroxybutyric acid in the blood rose from +64 milliequivalents per liter of plasma to 10.2 milliequivalents. Diuresis was accompanied with increased excretion of nitrogen, potassium, chlorides and sodium. The plasma sodium

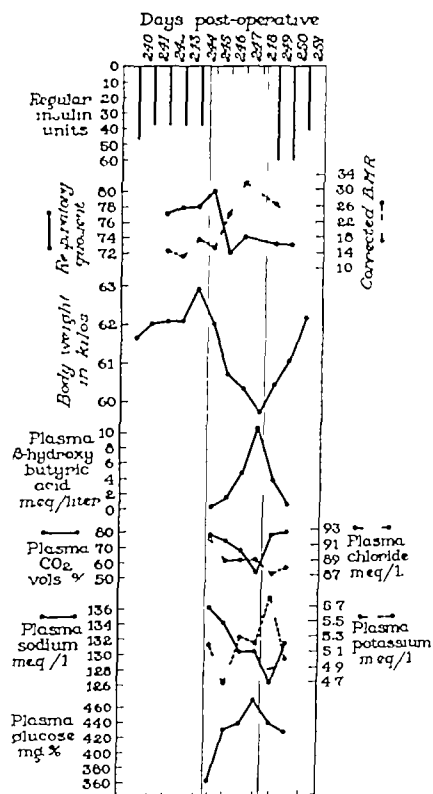


Fig 6—Insulin dosage, basal metabolic rate, respiratory quotient, weight and blood chemistry during second interval of insulin privation (indicated by two vertical lines)

fell to 126 milliequivalents per liter, and the potassium rose to 5.8 milliequivalents. In the first interval, appreciable ketosis was lacking and the carbon dioxide did not fall significantly, in the second interval, during the last few hours of insulin privation there was a small reduction of the carbon dioxide content to 52 volumes per hundred cubic centimeters of plasma.

The patient remained ambulatory during the second period of privation except during the last few hours. He complained of severe

diaphoresis during the second interval, whereas this did not occur during the first interval. Perspiration was pronounced, but this loss of body fluid was not measured. This prevented any attempt at balance studies. The patient observed another difference between the two intervals. In the first interval, diuresis was greater than in the second interval and was distributed equally through the day and night. On the other hand, in the second interval polyuria was greater at night than during the day, with an excretion of less than 1,500 cc in the daylight hours. In interpreting this, one should remember that in the daytime the patient was exercising, eating at four to six hour intervals and taking the salt mixture.

The respiratory quotients differed somewhat from those of the first interval in that the range on the preliminary basal run with insulin was 0.77 to 0.8 as compared with 0.87 to 0.95 in the first interval. This may have been the result of the lower carbohydrate intake of the second period. After the privation of insulin, quotients between 0.72 and 0.74 were obtained, which compare favorably with those of depancreatized animals. Much discussion without conclusions was provoked by the reciprocal relationship of the corrected basal metabolic rates and the respiratory quotients as noted in both intervals.

EFFECT OF TOTAL LACK OF EXTERNAL PANCREATIC SECRETION ON DIGESTION AND ABSORPTION

On the twenty-first postoperative day, the patient was ambulatory and in good general condition. He was eating an adequate diet, and the diabetes was under control. His weight was 56.7 Kg, and his basal caloric utilization was 1,680 calories as computed by the Boothby nomogram. His diet contained a daily average of 271.4 Gm of carbohydrate, 120.6 Gm of protein (19.3 Gm of nitrogen), 100.5 Gm of fat, 2.5 Gm of calcium and 2.3 Gm of phosphorus. The value for carbohydrate was estimated according to Sherman's tables, those for protein, fat, phosphorus and calcium were obtained by chemical analysis. These equaled 2,472.5 calories or approximately basal plus 50 per cent. After a preliminary period on this diet, the stools and the urine were collected during three periods of study. Period I (twelve days) included the twenty-fifth to thirty-sixth postoperative days inclusive, period II (six days) the thirty-seventh to forty-second postoperative days and period III (six days) the two hundred and thirty-second to two hundred and thirty-seventh postoperative days inclusive. The intake of food was isocaloric throughout the three periods. The program followed during period II differed from that of periods I and III in only one respect. During period II, 15 enteric-coated tablets of concentrated pancreatin (Wilson Laboratories) were given with each meal, a total of 45 tablets, or 15 Gm, a day. This increased

the average daily nitrogen intake from 19.3 to 20.98 Gm and of calcium from 2.5 to 4.64 Gm. The diabetes was well controlled with insulin throughout the periods of observation.

Another period of observation of six days, while the patient was taking pancreatin, was started but was interrupted by the development of abdominal pain and vomiting on the forty-fifth postoperative day. Subsequent investigation did not disclose obstruction of the gastrointestinal tract, nor have other similar attacks occurred since that time.

As previously mentioned, the patient was at home from the seventy-ninth to the two hundred and thirtieth postoperative day. For use during this interval, he was instructed in a qualitative diet containing approximately 408 Gm of carbohydrate, 98 Gm of protein and 102 Gm of fat. He was asked to take 8 enteric-coated tablets of pancreatin with each meal. His weight remained at approximately 61 Kg.

The urine and feces were collected in six day samples. The dried weight of the stool and its content of nitrogen, fat, calcium and phosphorus were determined for periods I, II and III, and the average daily loss was computed. The urine was analyzed for nitrogen, sugar, calcium and phosphorus. The beginning and the end of the periods were marked by the use of carmine. The values for total and neutral fat were determined by the method of Saxon,³ nitrogen by the method of Kjeldahl, carbohydrate by the method of Folin and Wu, calcium by the Clark-Collip modification of Kramer and Tisdall's method⁴ and phosphorus by the method of Kuttner and Lichtenstein.⁵

Gross Character of Stools—On each of the days of periods I and III (without pancreatin) one large, light-colored, fatty stool was passed. On each of the days on which pancreatin was administered, one stool was passed but the stool was smaller and darker than on other days. On the last of the six days during which pancreatin was taken, straining was required to pass the stool and bright red blood was noted. The darker color of the stool undoubtedly was partially due to the color of the enteric coating of the pancreatin tablets. It is of interest to note that the total lack of external pancreatic secretion did not produce frequent stools and that pancreatin changed the size and character of the stools. The patient later found that 8 tablets a day was sufficient to alter the gross character of the stools.

3 Hawk, P. B., Bergeim, O., Oser, B. L., and Cole, A. G. *Practical Physiological Chemistry*, ed. 11, Philadelphia, P. Blakiston's Son & Co., 1937 p. 378.

4 Clark, E. P., and Collip, J. B. *The Tisdall Method for the Determination of Blood Serum Calcium with a Suggested Modification*, *J. Biol. Chem.* **63**: 461-464 (March) 1925.

5 Kuttner, T., and Lichtenstein, L. *Micro Colorimetric Studies. II. Estimation of Phosphorus, Molybdic Acid-Stannous Chloride Reagent*, *J. Biol. Chem.* **86**: 671-676 (April) 1930.

Fecal Solids—During periods I and III, the dry weight of the stool averaged respectively 90.73 and 91.97 Gm a day (table 2). The dry weight of the feces was greater than that of normal subjects on the standard Schmidt test diet as reported by Pratt⁶. He found that the average daily weight of the dried feces of 6 normal persons over a period of three days was 54 Gm and that the maximum was 62 Gm.

During periods I and III respectively fat composed 52.71 per cent and 49.99 per cent of the fecal solids, as is shown in table 2 (range

TABLE 2—Average Daily Values for Fecal Solids

Period	Pan- creatin Given	Total, Gm	Fat Gm	Fat per Cent of Total	Nitro- gen as Protein Gm	Protein per Cent of Total	Fat and Protein per Cent of Total	Cal- cium, Gm	Phos- phorus, Gm
I (12 days)	0	90.73	47.82	52.71	41.25	45.46	98.17	1.845	0.998
II (6 days)	+	58.33	24.73	42.40	21.88	37.51	79.91	2.550	1.360
III (6 days)	0	91.97	46.98	49.99	37.00	40.23	90.22	1.210	0.899

in normal persons on a general hospital diet, 8.5 to 28.5 per cent, average, 18.5 per cent).⁷ During periods I and III respectively 30.93 and 37.52 per cent of the fecal fat was neutral fat (table 3).

In computation of the fecal nitrogen in terms of protein, the average daily protein (41.25 and 37 Gm) accounted for 45.46 and 40.23 per cent of the fecal solids respectively in periods I and III, fat and protein accounted for 98.17 and 90.22 per cent of the fecal solids respec-

TABLE 3—Average Daily Value for Intake of Fat in Food and Loss in Feces

Period	Pan- creatin Given	Intake Gm	Loss in Feces Gm			Per Cent of Fecal Fat as		Per Cent of Intake Lost as		
			Neu- tral	Split	Total	Neu- tral	Fatty Acid	Neu- tral	Fatty Acid	Total
I (12 days)	0	100.5	14.79	33.08	47.82	30.93	69.07	14.72	32.86	47.58
II (6 days)	+	100.5	6.67	18.06	24.73	26.97	73.03	6.64	17.97	24.61
III (6 days)	0	100.5	17.25	28.73	45.98	37.52	62.48	17.10	28.50	45.75

tively in periods I and III. In spite of the interval of six months separating these two periods, the values are closely similar.

The average daily fecal solids during period II, while pancreatin was given, weighed 58.33 Gm. Fat composed 42.4 per cent of the fecal solids, of the total fat, 26.97 per cent was neutral fat. The average daily protein (21.88 Gm) accounted for 37.51 per cent of the fecal solids, fat and protein accounted for 79.91 per cent. Thus, pancreatin

6 Pratt, J. H. Pancreatic Disease. The Frank Billings Lecture, J. A. M. A. 120:175-182 (Sept. 19) 1942.

7 Fowweather, F. S. The Determination of the Amount and the Composition of the Fat of Faeces. I. Investigation of a "Wet" Method and Comparison with the "Dry" Method, Brit. J. Exper. Path. 7:7-14 (Feb.) 1926.

reduced the average daily weight of the fecal solids approximately 35 per cent but did not change greatly the percentage of fat and nitrogen

Reducing Substances in Feces and Urine—Quantities of reducing substances in the feces were so small that they were not measured. The average daily values for reducing substances in the urine were 8.69 Gm during period I, 14.4 Gm during period II and 27.63 Gm during period III.

Nitrogen in the Feces and Urine—The intake and loss of nitrogen in the urine and feces are shown in table 4. Nitrogen loss in the

TABLE 4.—*Crude Daily Values for Intake of Nitrogen in the Food and Loss in Urine and Feces*

Period	Pancreatin Given	Intake Gm			Loss Gm			Balance, Gm	Per Cent of Intake Lost in Urine	Per Cent of Intake Lost in Feces
		Food	Pancreatin	Total	Urine	Feces	Total			
I (12 days)	0	19.3		19.30	12.09	6.00	18.09	+0.61	62.64	34.20
II (6 days)	+	19.3	1.65	20.98	13.96	3.50	17.46	+3.52	66.54	16.68
III (6 days)	0	19.3		19.30	12.82	5.92	18.74	+0.56	66.42	30.67

feces averaged 6.6 and 5.92 Gm per day respectively in periods I and III (without pancreatin) and 3.5 Gm per day during period II, when pancreatin was given. By the use of pancreatin, during period II, the average daily loss of nitrogen was reduced 3.1 Gm from that of period I and 2.4 Gm from that of period III. The daily loss of nitrogen in the urine was 12.09 and 12.82 Gm respectively during periods I and III, without pancreatin, and 13.96 Gm during period II, with pancreatin. The nitrogen balance was +0.61 and +0.56 Gm a day respectively during periods I and III and +3.52 Gm during period II. The loss of weight was 0.82 Kg during period I and 0.87 Kg during period III, but weight was gained (0.67 Kg) during period II, while the patient was on the same diet with pancreatin. Total lack of external pancreatic secretion caused a large loss of nitrogen in the stools, but the nitrogen balance was slightly positive. The effect of the total lack of external pancreatic secretion observed in period III was remarkably similar to that observed six months earlier in the immediate postoperative period. Pancreatin given during period II reduced the loss of nitrogen in the feces by 47 per cent, as compared with that of period I, increased the nitrogen balance and converted a tendency toward loss of weight toward gain of weight.

Fat in the Feces—The intake of fat averaged 100.5 Gm a day in all three periods of observation (table 3). The average daily losses in the stools were 47.82 and 45.98 Gm respectively in periods I and III (no pancreatin given) and 24.73 Gm in period II (pancreatin given). The amount of fat that was lost in the stool was 47.58 and

45.75 per cent of the ingested fat during periods I and III and 24.61 per cent during period II. Part of the loss of fat may be attributed to the partial gastrectomy with end to side gastrojejunostomy. The fat lost in the stools as compared with the amount ingested after this surgical procedure averaged approximately 14 per cent in more than 10 cases, while the fat lost in the stools of normal persons on a high fat diet averaged about 4.5 per cent.⁸ Most of the loss of fat in our case was due to lack of pancreatic secretion.

Neutral fat lost in the stools averaged 14.79 and 17.25 Gm respectively in periods I and III (no pancreatin given) and 6.67 Gm in period II (pancreatin given). Neutral fat composed 30.93 and 37.52 per cent of the total fat lost respectively in periods I and III and 26.97 per cent during period II.

The complete lack of external pancreatic secretion resulted in a large loss of fat, but splitting of fat was highly successful in spite of the absence of the pancreatic enzymes. This has been a matter of comment by Pratt⁹ and others. The effect of the total lack of external pancreatic secretion observed in period III was remarkably similar to that observed six months earlier, during period I (immediate post-operative period). Pancreatin considerably reduced the loss of fat but did not produce much change of the percentage lost as neutral fat.

Effect of Loss of Food in Feces and Urine on Caloric Balance — The caloric values of the ingested food and of the foods recovered in the urine and feces are shown in table 5. Metabolic fecal fat and nitrogen have been ignored in computation of the balance.

The average daily loss of calories was 590.88 in the feces and 34.76 in the urine in period I. This represented a loss of 23.9 per cent in the stools and 1.4 per cent in the urine, or 25.3 per cent in both feces and urine. There were 1,846.86 calories (only 166.86 calories more than the estimated basal needs) utilized, and a loss of weight of 0.82 Kg occurred during this period. The data for period III are similar to those for period I. The loss of foodstuffs following total pancreatectomy was sufficiently great to affect nutrition and to increase the amount of food necessary for maintenance of weight.

Pancreatin reduced the caloric loss in the feces from 590.88 in period I to 310.1 in period II (the percentage of calories lost in the feces reduced from 23.9 in period I to 12.5 in period II), increased the calories utilized from 1,846.86 in period I to 2,104.8 in period II (257.94 calories) and reversed a slow loss of weight during period I, of 0.82 Kg (averaging approximately 0.07 Kg a day), to a gain of weight of 0.67 Kg during period II (approximately 0.11 Kg a day).

⁸ Wollaeger, E. E., Comfort, M. W., Weir, J. F., and Osterberg, A. E. The Total Solids, Fat and Nitrogen in the Feces. I and II, *Gastroenterology* 6: 83-104 (Feb.) 1946.

TABLE 5—Average Daily Values for Calories Ingested and Lost in Urine and Feces

Period	Pan creatin Given	Intake Calories			Loss, Calories				Balance, Calories	Basal Require ment, Calories	Per Cent of Intake Lost in Feces and Urine
		Carbo hydrate	Protein	Fat	Total	Fecal Fat	Fecal Protein	Urinary Sugar	Total		
I (12 days)	0	1,085.6	482.4	904.5	2,472.5	4.25 88	105.0	34.76	625.64	1,846.86	25.3
II (6 days)	+	1,085.6	482.4	904.5	2,472.5	2.22 60	87.5	57.60	367.70	2,104.80	14.9
III (6 days)	0	1,085.6	482.4	904.5	2,472.5	411.82	148.0	110.52	672.34	1,800.16	27.2

TABLE 6—Values for Plasma Lipids (Cholesterol, Cholesterol Esters, Lecithin, Fatty Acids, Total Lipids), Serum Calcium, Phosphorus, Protein and Bilirubin, Albumin-Globulin Ratios, Sulfobromophthalan Tests of Hepatic Function, Hemoglobin Levels and Erythrocyte and Leukocyte Counts

Determination	Normal Values			Postoperative Day												
	Low	High	Average	4th	15th	25th	30th	30th	42d	50th	60th	60th	75th	231st	242d	250th
Plasma lipids, mg per 100 cc plasma																
Cholesterol	175	354	244		200	300	267	210	234	203	234	247	267	237	320	237
Cholesterol esters	120	268	174		120	183	159	147	172	142	90	164	124	151	181	156
Lecithin	186	300	235		277	360	357	332	380	369	318	269	360	347	277	238
Fatty acids	253	570	384		415	814	802	712	683	681	592	532	783	469	478	471
Total lipids	401	827	628		615	1,114	1,060	922	817	784	826	770	1,050	606	708	708
Calcium, mg per 100 cc serum	9.0	11.0			8.4	10.0	9.0	9.0	10.4	10.3	10.6	10.7	10.7	10.1	10.7	10.7
Phosphorus, mg per 100 cc serum	3.0	4.0			5.7	6.7	4.6	4.6	3.8	4.0	4.0	4.8	3.5	3.5	3.7	3.7
Bilirubin, mg per 100 cc serum																
Direct				0						0	0	0	0	0		
Indirect		0.6			0.9					0.3	0.2	0.4	0.4	1.3		
Protein, Gm per 100 cc serum	6.0	8.0		6.1	5.9	6.8	7.0	7.0	7.9	7.3	7.1			7.6		
Albumin globulin ratio	1.5:1	3:1			1.3:1	1.19:1	1.28:1	1.24:1	1.10:1	1.19:1			1.26:1	1.5:1	1.44:1	
Sulfobromophthalan test of hepatic function				0		0	0	0	0	0	1		0	0		
Hemoglobin, Gm per 100 cc blood	14.0	17.0		9.0	10.45	10.45	10.45	11.5	11.8	11.05	10.9	12.4	12.0	11.9	13.8	
Erythrocytes * per cu mm	4.25	5.25			3.69	3.09	3.61	4.10	4.33	4.12	3.8	3.9	4.6	4.67	4.85	
Leukocytes per cu mm	5,000	9,000		23,400	12,100	8,400	6,700	12,200	10,800	9,000	6,400	8,600	7,000	14,200	11,200	

* Million

Effect of Total Lack of External Pancreatic Secretion on Loss of Calcium and Phosphorus in Feces and Urine—The average daily content of calcium and phosphorus in the diet was respectively 2.5 and 2.3 Gm during periods I and III. The daily loss in the urine averaged 0.216 and 0.38 Gm of calcium and 1.086 and 1.43 Gm of phosphorus respectively in periods I and III and the daily loss in the feces averaged 1.85 and 1.21 Gm of calcium and 0.908 and 0.89 Gm of phosphorus respectively during periods I and III. Although the data are not reliable for calcium and phosphorus balances, it appears that the loss of calcium in the feces while the patient was receiving 2.5 Gm a day was not excessive, in spite of the large loss of fat in the feces. It is generally accepted, on the contrary, that poor utilization of fatty acids and fats interferes with absorption of calcium because it leaves fatty acids in the intestine to form insoluble calcium soaps.⁹ The daily excretion of calcium in the urine was of sufficient magnitude to suggest a reasonably normal absorption of calcium from the gastrointestinal tract.

EFFECT OF TOTAL PANCREATECTOMY ON BLOOD LIPIDS AND HEPATIC FUNCTION

The values for plasma lipids, serum calcium, phosphorus, bilirubin and proteins, the albumin-globulin ratios, the degree of dye retention on sulfobromophthalein tests for hepatic function, the hemoglobin levels and the erythrocyte and leukocyte counts secured during the post-operative periods of observation are given in table 6. The values for plasma lipids in persons of the same age group¹⁰ as our patient, the normal values for serum calcium, phosphorus and protein and the normal albumin-globulin ratios also are shown in table 6.

The total fat and cholesterol were determined by the method of Bloor,¹¹ lecithin by the method of Youngburg and Youngburg,¹² cholesterol esters by the method of Bloor and Knudson,¹³ calcium by the Clark-Collip⁴ modification of the Kramer and Tisdall method, phosphorus by the method of Kuttner and Lichtenstein,⁵ bilirubin by

9 Peters, J. P., and Van Slyke, D. D. *Quantitative Clinical Chemistry*, Baltimore, Williams & Wilkins Company, 1931, vol. 1, chap. 16, pp. 805-861.

10 Barker, N. W. *The Plasma Lipoids in Arteriosclerosis Obliterans*, *Ann Int Med* **13**: 685-692 (Oct.) 1939.

11 Bloor, W. R. *The Determination of Cholesterol in Blood*, *J. Biol. Chem.* **24**: 227-231, 1916; *The Determination of Small Amounts of Lipid in Blood Plasma*, *ibid.* **77**: 53-73 (April) 1928.

12 Youngburg, G. E., and Youngburg, M. V. *Phosphorus Metabolism. I. A System of Blood Phosphorus Analysis*, *J. Lab. & Clin. Med.* **16**: 158-166 (Nov.) 1930.

13 Bloor, W. R., and Knudson, A. *The Separate Determination of Cholesterol and Cholesterol Esters in Small Amounts of Blood*, *J. Biol. Chem.* **27**: 107-112, 1916.

the method of Sepulveda and Osterberg,¹⁴ protein by the mass Kjeldahl method and the albumin-globulin ratio by the Kingsley method¹⁵

It is interesting to note that definite hyperlipemia developed by the twenty-fifth postoperative day. The rise of values for cholesterol and cholesterol esters was of short duration and was not great enough to pass the upper limits of the so-called normal range of values. The rise of values for lecithin, fatty acids and total lipids was persistent and of sufficient magnitude to exceed the upper limits of normal range of values. These concentrations remained near or above the upper limits through the seventy-fifth postoperative day. Insulin was withheld on the sixty-seventh, sixty-eighth and sixty-ninth postoperative days, without definite effect on the concentration of plasma lipids on the sixty-ninth day. The values for plasma lipids declined in the interval between the seventy-fifth and the two hundred and thirty-first postoperative day. On the two hundred and thirty-first, two hundred and forty-second and two hundred and fiftieth postoperative days the values were within the range found in normal persons of the same age group. Withholding of insulin on the two hundred and forty-fifth, two hundred and forty-sixth and two hundred and forty-seventh postoperative days did not noticeably affect the level of concentration of plasma lipids as obtained on the two hundred and fiftieth day.

Hepatic function was satisfactory throughout the period of study. The serum bilirubin remained normal, and the van den Bergh reaction was indirect. The serum proteins increased, reaching high normal values toward the end of the period of observation. The albumin-globulin ratio also became normal. A sulfobromophthalein test of hepatic function did not disclose dysfunction except in one test, on the sixtieth postoperative day, when retention of dye occurred. The retention was only 6 per cent (upper limit of normal 5 per cent) and was transitory. It is doubtful whether this retention of dye was significant.

Total pancreatectomy produced dissimilar results in our patient from those following total pancreatectomy in dogs. When a depancreatized dog is maintained with insulin and a diet adequate to maintain a normal dog, infiltration of the liver with fat, decreased requirement for insulin, decreased output of sugar in the urine and about a 50 per cent reduction in blood fats develop.¹⁶ These changes may take place

14 Sepulveda, B, and Osterberg, A E. Serum Bilirubin Procedure for Determination of Indirect and Direct Values, *J Lab & Clin Med.* **28** 1359-1368 (Aug) 1943, correction, *ibid* **28** 1654 (Oct) 1943

15 Kingsley, G R. A Rapid Method for the Separation of Serum Albumin and Globulin, *J Biol Chem* **133** 731-735 (May) 1940

16 Dragstedt, L R. Some Physiologic Problems in Surgery of the Pancreas. *Ann Surg* **118** 576-589 (Oct) 1943. Dragstedt, L R, Clark D E, and Ver-

within four to five weeks or earlier and are well developed by the twentieth week. The reduced function of the liver is measurable with the sulfobromophthalein test¹⁷. These findings have appeared when the depancreatized dog has been fed a high protein, low carbohydrate, low fat diet,¹⁸ a high protein, high carbohydrate, low fat diet¹⁹ or a high protein, high fat (40 per cent) diet,²⁰ with or without vitamin supplements. A lipotropic substance, either raw pancreas, lipocaic, lecithin or choline, must be added to prevent these changes. Dragstedt has found that the minimal effective daily dose of choline for a dog weighing 9 to 14 Kg. is about 1 Gm.²¹

In the case reported in this paper, the patient received first a mixed diet containing about 270 Gm. of carbohydrate, 108 Gm. of protein and 100 Gm. of fat and later a mixed diet containing about 400 Gm. of carbohydrate, 100 Gm. of protein and 100 Gm. of fat with insulin and was not given raw pancreas, lipocaic, choline or pancreatin during the first five weeks. Hyperlipemia instead of hypolipemia developed and hepatic dysfunction, indicating infiltration of the liver with fat, did not appear. After the thirty-sixth postoperative day, the patient received 15 Gm. and later 10 Gm. of enteric-coated pancreatin, and by the two hundred and fiftieth postoperative day he still did not show hypolipemia or disturbed hepatic function.

On the basis of comparative weights (130 pounds [59.0 Kg.] for our patient and 26½ pounds [12 Kg.] for the dog) and calculating roughly from the amount of choline necessary to prevent the typical

meulen, C. The Significance of Lipocaic in Surgery, *ibid.* **110** 907-914 (Nov.) 1939. Dragstedt, L. R. The Present Status of Lipocaic, *J. A. M. A.* **114** 29-32 (Jan. 6) 1940. Rubin, S. H., and Ralli, E. P. The Effect of Depancreatization and Ligation of the Pancreatic Ducts on the Blood and Liver Lipids of Dogs, *Am. J. Physiol.* **129** 578-584 (June) 1940.

17 Goodpasture, W. C., Vermeulen, C., Donovan, P. B., and Dragstedt, L. R. The Bromsulphalein Liver Function Test as a Method of Assay of Lipocaic, *Am. J. Physiol.* **124** 642-646 (Dec.) 1938.

18 Montgomery, M. L., Entenman, C., and Chaikoff, I. L. The Liver Lipids of Dogs Subjected to Ligation of the External Pancreatic Ducts, *J. Biol. Chem.* **128** 387-398 (May) 1939.

19 Best, C. H., Hershey, J. M., and Huntsman, M. E. The Control of the Deposition of Liver Fat, *Am. J. Physiol.* **101** 7 (June) 1932. Ralli, E. P., Flaum, G., and Banta, R. The Results of Feeding Lecithin and Pancreas in Depancreatized Dogs on the Liver Fat and Its Saponifiable and Unsaponifiable Fractions, *ibid.* **110** 545-551 (Jan.) 1935. Montgomery and others¹⁸.

20 Dragstedt, L. R., Van Prohaska, J., and Harms, H. P. Observations on a Substance in Pancreas (a Fat Metabolizing Hormone) Which Permits Survival and Prevents Liver Changes in Depancreatized Dogs, *Am. J. Physiol.* **117** 175-181 (Sept.) 1936.

21 Van Prohaska, J., Dragstedt, L. R., and Harms, H. P. The Relation of Pancreatic Juice to the Fatty Infiltration and Degeneration of the Liver in the Depancreatized Dog, *Am. J. Physiol.* **117** 166-174 (Sept.) 1936.

changes in the depancreatized dog, our patient needed about 5 Gm of choline a day to protect him against the development of a fatty liver and hypolipemia. Apparently he received much less than this. On the basis of a diet containing 100 Gm each of green beans, carrots, asparagus and rice, 200 Gm of Irish potatoes, 120 Gm of bread, 700 Gm of whole milk, 2 egg yolks and 150 Gm of meat, the patient received each day approximately 1.8 Gm of choline, according to the values for choline in various foodstuffs supplied by Engel²² and by McIntire, Schweigert and Elvehjem²³. To this was added, after the thirty-sixth postoperative day, the amount of choline and lipocain present in the pancreatin. Each tablet of concentrated pancreatin of the manufacture used (Wilson Laboratories) contains 1.8 mg of choline²⁴. On the basis of 30 tablets a day (the approximate dose used during most of the period of observation), the pancreatin added only 54 mg of choline a day to that obtained in the diet. It is of interest to note in passing that pancreatin is a poor source for choline, since approximately 140 tablets of pancreatin are needed to supply the choline in 1 egg yolk. The pancreatin given to this patient contained an amount of choline too small to influence significantly the development of infiltration of the liver with fat.

Dragstedt²⁵ has found that 10 Gm of pancreatin supplies an effective daily dose of lipocain to the average-sized depancreatized dog. Again, on a comparative basis of weights, the amount of lipocain given to the patient appears inadequate.

The possibility that in the case reported in this paper the changes appearing in the depancreatized dog may ultimately develop has not been forgotten. A satisfactory explanation, in the light of experience with the depancreatized dog, of the failure of hypolipemia and infiltration of the liver with fat to develop in the case of this depancreatized human being, as well as 10 per cent of depancreatized dogs, is not readily found. It would be interesting to know whether hyperlipemia existed before the development of carcinoma of the pancreas and before pancreatectomy. Attention may be called to the fact that the spleen, the duodenum and part of the stomach in addition to the pancreas were removed from our patient whereas only the pancreas was removed from the depancreatized dog, but this difference does not appear at this time to explain the difference in results so far obtained. It seems

22 Engel, R. W. Modified Methods for the Chemical and Biological Determination of Choline, *J. Biol. Chem.* **144** 701-710 (Aug.) 1942, The Choline Content of Animal and Plant Products, *J. Nutrition* **25** 441-446 (May) 1943.

23 McIntire, J. M., Schweigert, B. S., and Elvehjem, C. A. The Choline and Pyridoxine Content of Meats, *J. Nutrition* **28** 219-223 (Oct.) 1944.

24 Klein, D. Personal communication to the authors.

25 Dragstedt, L. R. Personal communication to the authors.

more likely that the differences between the diets given to our patient and those given to the depancreatized dog may be important. The comment of McHenry and Patterson,²⁶ in their recent review of lipotropic factors, that "The present situation with regard to the cause and prevention of fatty livers in depancreatized dogs is that there are a number of unanswered questions" seems to apply equally to the depancreatized human being.

Certain abnormal morphologic characteristics of the cellular elements of the blood were noted. Macrocytosis due to increased regeneration and Howell's bodies (presumably due to splenectomy) were observed. The myeloid immaturity, which extended to the promyelocytes, was difficult to explain, since there was no evidence of metastasis. This blood picture was essentially the same in the late period of observation, except for fewer macrocytes. The number of erythrocytes and the amount of hemoglobin returned gradually to a normal level.

SUMMARY AND CONCLUSIONS

The studies reported in this paper on the effect of the lack of internal and external secretions of the pancreas in a totally depancreatized human being were performed as a pilot study for future work on the problem. From the cases of pancreatectomy presented in the literature²⁷ and from those in which it was performed at the Mayo Clinic it would seem that a depancreatized adult requires about 20 to 70 units of insulin daily during the first week or so after operation and about 25 to 40 units daily for maintenance thereafter. Whereas the severity of diabetes may be determined superficially by the amount of insulin needed for a given degree of control, the tendency of persons who have diabetes mellitus toward the development of ketosis varies tremendously.

The changes in the blood and urine during two periods of insulin privation of eighty-nine hours each in the case of a diabetic man who underwent total pancreatectomy because of an adenocarcinoma, grade 2 (Broders' method), were as follows. When 440 Gm of carbohydrate were given the ketonemia was slight, and when 125 Gm were given the ketonemia was pronounced. These data, with respect to the diabetic status before and after pancreatectomy, are presented as a contribution to our knowledge of diabetes in depancreatized man.

Total pancreatectomy did not produce diarrhea in spite of the large amount of fat in the stools. The bulkiness of the stools was reflected

26 McHenry, E. W., and Patterson, J. M. Lipotropic Factors, *Physiol. Rev.* **24**: 128-167 (Jan) 1944.

27 Fallis, L., cited by McClure, R. D., in discussion on Brunschwig, A. The Surgical Treatment of Carcinoma of the Body of the Pancreas, *Ann. Surg.* **120**: 406 (Sept) 1944.

in abnormally high values for their dry weight. Fat and protein in the feces accounted for most of their dry weight.

Total pancreatectomy was followed by considerable reduction in digestion and absorption of protein and fat. About a half of the ingested fat and about a third of the ingested protein were lost in the feces. Digestion of fat was surprisingly good, as only about a third of the fat in the feces was neutral fat. The absorption of calcium and phosphorus was apparently adequate in spite of the high loss of foodstuffs in the stools.

Concentrated pancreatin in enteric-coated tablets (15 with each meal, or 15 Gm daily) was found to reduce the loss of fat and protein by approximately 50 per cent. It also reduced the dry weight of the feces and altered the gross appearance of the stool. Concentrated pancreatin reduced the loss of calories sufficiently to cause the patient to gain weight slightly over the short period of study rather than lose weight. The amounts of fat and nitrogen lost in the feces even when pancreatin was given were in excess of normal values. Although concentrated pancreatin in the doses given was not a complete substitute for external pancreatic secretion, it was definitely valuable in maintaining the nutrition of the patient.

In our case, total pancreatectomy was not followed during the eight months of observation by a decrease in the amount of glucose lost in the urine or of the insulin requirements or by hypolipemia and hepatic dysfunction indicative of a fatty liver, as is often the case in pancreatectomized dogs. On the contrary, the patient's diabetes remained of about the same severity, the protamine zinc insulin requirement being approximately 40 units a day. Hepatic function as measured by the sulfobromophthalein test remained unimpaired throughout the eight months of observation, and hyperlipemia rather than hypolipemia appeared. The patient remained in good health and maintained his weight while taking a mixed diet plus insulin and 10 Gm of concentrated pancreatin. His condition was reported as good twelve months after operation.

PARENTERAL ADMINISTRATION OF FLUIDS DURING THE EARLY CARE OF BATTLE CASUALTIES

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THE manner of handling the administration of parenteral fluid needed during the early care of a series of closely observed battle casualties constitutes the basis for this report

The casualties occurred in the New Guinea, Bismarck Archipelago and Philippine areas. Observations were conducted mainly aboard an LST acting as a casualty ship during the early phases of amphibious operations. Casualties were received from ships damaged during the landing phases and from troops landed on the invasion beaches

TYPES OF CASES

An analysis of cases of 345 patients will be made (68 per cent of the total patients treated). Tables 1, 2 and 3 contain information concerning the types of injuries encountered

TABLE 1—*Frequency of Types of Injuries*

Types of Injuries	Cases	
	Number	Percentage
Fractures and lacerations	108	31.3
Lacerations no fracture	100	28.95
Abdominal injuries	25	7.24
Thoracic injuries	11	3.18
Head injuries	7	2.02
Burns	54	27.24
Total	345	99.06

In table 1 the frequency of the types of injuries is given. Outside the group with burns 51.2 per cent of the patients sustained multiple injuries, that is, multiple lacerations of skin, muscles or other parts, with or without fractures. The group with abdominal injuries included patients with perforation of the abdominal wall and injury

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to one of the viscera, the group with thoracic injuries sustained perforation of the thoracic cage, the group with head injuries presented injury about the head and mental and/or neurologic signs. The group with fractures can be further subdivided into patients with fractures of extremities (92.5 per cent [femur 27 per cent, tibia 40 per cent and upper extremities 33 per cent]) and patients with compound fractures (78 per cent).

There are two types of information in table 2, expressed on the basis of frequency distribution: (1) the time interval between the occurrence of the injury and the first observation by us and (2) the specific gravity values of whole blood and serum prior to therapy, distributed as to level and in relation to the time since injury.

The patients are divided into two groups: group I, with lacerations, with or without fractures, and group II, with burns, with or without involvement of subcutaneous tissues.

The percentages of patients seen within forty-eight hours or less following the injury were 62.2 per cent for group I and 88.4 per cent for group II. In accordance with previously established normal ranges,¹ certain observations can be additionally made. In group I, 88.85 per cent of the patients displayed a specific gravity of the blood in the lower limits of normal or below, and 66.5 per cent had values definitely below normal, 98.6 per cent displayed a specific gravity of the serum at the lower limits of normal or below, and 60.5 per cent had values definitely below normal. Of the patients definitely below normal for specific gravity of the blood, 16.1 per cent were seen between one-half hour and eight hours, 40.6 per cent between nine and forty-eight hours and 43.2 per cent after forty-eight hours; for specific gravity of the serum the corresponding figures are 16.6 per cent, 42 per cent and 41.3 per cent.

In group II, 71.2 per cent of the patients had specific gravities of the blood in the upper limits of normal or beyond and 25.5 per cent had values definitely above normal but only 4.2 per cent had specific gravities of the serum in the upper limits of normal or beyond, 28.7 per cent demonstrated blood values at lower limits of normal or below, the corresponding figure for specific gravity of the serum being 41.4 per cent.

In table 3 an indication of the volume of various fluids given to patients with the different types of injuries is given. The greatest volumes of blood were given to the group with "lacerations-fractures" whose specific gravity values were lowered and the greatest volume-

1. Muirhead, E. E., Grow, M. H., and Walker, A. T. Practical Observations on the Copper Sulphate Method for Determining the Specific Gravities of Blood and Serum, *Surg., Gynec. & Obst.* 82: 405-413 (April) 1946.

TABLE 2—Time Interval Between Injury and Treatment and Specific Gravity Values

Time from Injury to Observation	Specific Gravity	Number of Patients with Lacerations—Fractures										Number of Patients with Burns							
		Number of Patients with Lacerations—Fractures										Number of Patients with Burns							
		1 030 to 1 040+	1 041 to 1 050+	1 051 to 1 060+	1 061 to 1 070+	1 071 to 1 080+	1 081 to 1 090+	1 091 to 1 100+	1 101 to 1 110+	1 111 to 1 120+	1 121 to 1 130+	1 030 to 1 040+	1 041 to 1 050+	1 051 to 1 060+	1 061 to 1 070+	1 071 to 1 080+	1 081 to 1 090+	1 091 to 1 100+	Total
0 5 to 8+ hrs	Blood	2	23	15	7														
	S	4	18	22											7				11
9 to 24+ hr	B	7	26	19	4														23
	S	7	21	24	1							3	9	16					28
25 to 48+ hr	B	10	20	5	6														40
	S	10	18	13	1		1					5	15	24					44
49 to 72 hr	B	0	11	2	3														6
	S	4	10	6								2	1					1	3
3 to 5+ days	B	8	12	3	1														3
	S	12	8	4								2		1					3
6 to 10+ days	B	7	16	6	4														1
	S	7	14	8	1								1						1
11 to 20 days	B		7	2															9
	S			6															2
Total	B	40	115	62	25		1												94
	S	44	80	83	3							12	27	49					92

of normal plasma and concentrated albumin were given to the patients in the group with "burns." Notice that larger volumes were frequently considered necessary to cope with the deviations of the criteria used for the appraisal of fluid needs

TABLE 3—*Volume of Fluids Given Patients in Different Types of Cases*

Types of Cases	Blood (Cltrated) Cc				Total Cases	Total Volume Cc
	500 to 900+	1 000 to 1,900+	2 000 to 3 000+	3 100 to 4 000+		
Laceration and fractures						
Specific gravity near normal	0	15	1	1	23	29 650
Shock specific gravity low	1	14	14	8	37	93,275
Anemia etc specific gravity low	7	18	27	6	58	112,200
Burns						
Specific gravity near normal		2	1		3	4,360
Shock, etc, specific gravity high	1	1	2		4	6 355
Total	15	50	45	15	125	245 780

Types of Cases	Plasma (Normal) Cc				Total Cases	Total Volume Cc
	250 to 500+	600 to 900+	1 000 to 2 000+	2 100 to 3 000+		
Laceration and fractures						
Specific gravity near normal	28	8	14	2	52	39,000
Shock, specific gravity low	8	4	13	3	28	38 825
Anemia, etc, specific gravity low	9	5	18	2	34	30 450
Burns						
Specific gravity near normal	26	8	7	1	42	27 150
Shock, etc specific gravity high	2	1	17	7	27	64 200
Total	73	26	69	15	183	199 625

Types of Cases	Dextrose in Isotonic Solution of Sodium Chloride (5 per Cent) Cc				Total Cases	Total Volume Cc
	1 000 to 1 900+	2 000 to 2 900+	3 000 to 4 000+	4 100 to 5 000+		
Laceration and fractures						
Specific gravity near normal	15	1	2	1	19	27 000
Shock specific gravity low	3	2		1	6	13 900
Anemia etc specific gravity low	3	1	1	1	8	16 600
Burns						
Specific gravity near normal	6		1		7	9 000
Shock etc. specific gravity high	5	3	2		10	17 500
Total	32	9	6	3	50	84 000

Types of Cases	Albumin * (Concentrated Solution) Cc				Total Cases	Total Volume Cc
	100	200	300 to 400+	500+		
Laceration and fractures						
Specific gravity near normal	2	3	2	1	8	2 100
Shock specific gravity low	2	2	5	2	11	1 100
Anemia, etc, specific gravity low	1	4			5	600
Burns						
Specific gravity near normal	1	5	2		8	1 500
Shock etc specific gravity high	2	4	7	5	18	1 500
Total	8	18	16	8	50	11 700

* In addition 3550 cc of concentrated plasma (threefold or fourfold) were administered to 8 patients

For the purpose of this paper, the patients are divided into two main categories (1) those with loss of blood following the trauma (hemorrhagic type) and (2) those with loss of plasma (plasmorrhagic type). Casualties in group 1 had various degrees of lacerations, with or without fractures, or crushing injuries, with torn-open blood vessels. Group 2 was composed primarily of patients with burns, resulting in increased capillary permeability.

The time interval between injury and arrival aboard the casualty ship was used to subdivide each group additionally: (a) patients observed during the first twenty-four or thirty-six hours, when "shock" was more apt to occur (except in cases in which major operations were performed later and a new such "shock period" was considered), and (b) patients first observed after thirty-six to forty-six hours, when more stabilized grades of circulatory compensation had occurred. For the latter patients the emphasis was shifted toward the replenishment of specific elements which had been lost (red cells, proteins, salts and vitamins) and toward the supply of metabolic needs. These replacements were needed to encourage healing of wounds, to combat infection and to prevent the wastage of body tissues. Although no sharp line of demarcation can be drawn, this categoric separation into clinical types seemed worth while despite variable degrees of overlapping.

CRITERIA FOR APPRAISAL OF CASES

The appraisal of needs for parenteral administration of fluid was based on four major criteria. Emphasis was placed on the repeated comparisons of the more relevant features of these criteria.

I Clinical Picture—A grouping of strictly clinical features is discussed in five phases.

A History In taking the history, emphasis was placed on circumstances surrounding the injury, traumatizing agent, time of injury, blood loss, previous therapy (blood, plasma, morphine and operations), unconsciousness and special or localizing complaints, such as loss of sensation in a foot.

B Physical Findings Besides the usual physical examination, main interest was centered in

- 1 Site of injury This included location, type and condition of wounded parts.
- 2 Volume of pulse This was considered much more important than the pulse rate.

- 3 State of veins The degree of conspicuousness of superficial veins below the heart was related to the loss of blood volume in "shock." This was compared with the volume of blood or blood substitute necessary to effect recovery. The usual concept of the compensatory mechanism in severe loss of blood embraces a general vasoconstriction during oligemia which is greater in the somatic zones (skin, subcutaneous tissue and muscle) than in the vital organs, thus protecting visceral areas (brain, heart, lungs, liver, kidneys and other organs).

While plasma, albumin solution or citrated blood was administered, it was not considered necessary to become concerned over the volume given, so long as the veins were closely observed. Blood and blood derivatives were given until the peripheral veins showed normal filling. The opposite extreme to shock (volume overload) is difficult to attain in casualties who have lost large amounts of circulating volume. The latter condition is characterized by obvious venous engorgement and pulmonary rales in dependent areas.

4 State of skin. A change from the characteristic fulness and spongy recoil of normally hydrated skin (persons of military age) to dryness, stickiness and ridging when pinched were taken as the obvious signs of loss of tissue turgor.

Experimental dehydration has demonstrated the loss of water from large stores in the skin, subcutaneous tissues and muscles first, vital organs being protected until late.² Dogs acutely dehydrated with 50 per cent dextrose lose cutaneous turgor rather late.³

Casualties observed during early hours and those able to take water orally seldom exhibited loss of cutaneous turgor. This state of adequate hydration was considered the explanation for the prompt effectiveness of concentrated protein solutions (albumin and plasma) in coping with oligemia in freshly wounded casualties or those able to ingest adequate amounts of fluid.

Other cutaneous signs used in detection of shock were pallor, sweating and cyanosis.

5 Other observations included the state of the respiratory system, the condition of the pupils (morphine), the presence or absence of fever, the presence of devitalized limbs and roentgenologic examinations when possible.

C Mental State. The main cerebral signs in shock were disorientation, restlessness, dulness and coma. In the absence of injury to the head, these signs were considered extremely important. These signs diminished only after the circulating volume had been reestablished.

D Renal State. Return to normal urinary output and specific gravity were taken as the main indications of an adequate water intake and rehydration. This return to normal was observed in most cases after the correction of the oligemia.

The presence of albumin, red cells and casts in the urine indicated a poor prognosis, the gravity of the prognosis increased with persistence of these urinary findings.

E Dietary Needs. Persons unable or unwilling to ingest enough food by mouth required supplements given parenterally. Protein as plasma proteins, dextrose, salts and vitamins were administered in varying quantities. Two factors were constantly considered. 1 Severely burned and severely injured patients frequently require two to three times the normal daily protein intake. 2 Infused red cells not only serve their specific functions but in cases of depletion spare proteins for other purposes (replenishment of protein stores, increase in circulating plasma proteins, repair of wounds and combat of infections). This is in accordance with the concept of Whipple and Madden.⁴

2 Flemister, L. J. Distribution of Available Water in Animal Body, *Am J Physiol* **135** 430-438 (Jan.) 1942.

3 Muirhead, E. E., and Hill, J. M. Unpublished data.

4 Whipple, G. H., and Madden, S. C. Hemoglobin Plasma Protein and Cell Protein—Their Interchange and Construction in Emergencies, *Medicine* **23** 215-224 (Sept.) 1944.

II *Blood Pressure*—Naturally blood pressure, a variable finding, was of greatest value when lowered in a shock suspect. A pressure that was depressed for thirty minutes in a wounded man was considered to have been effected by more than neurogenic influences. Oligemia was found to be the main reason for a significant drop in blood pressure. Hypertensive intervals in hemorrhagic patients were observed to be transient in a low percentage of cases and were usually followed by sudden drops to critically hypotensive levels. With the blood pressure at normal levels, appraisal of the severity of the shock rested on other criteria.

III *Concentration Studies*—A preliminary consideration of the measurements of specific gravity by the copper sulfate method conducted in these cases has been made.¹ These studies reflect the concentration of red cells and proteins in unit volumes of blood and serum respectively. In wounded men with normal or near normal hydration, the persistent dilution of these elements was taken as indicative of a lowering in the total bulk of these elements. The concentration of red cells in the cases of burns was indicative of a lowered plasma volume and a decrease in the bulk of circulating proteins.

In the absence of rapid means of determining the total bulk of red cells and proteins, this method became extremely important. Attempts were made to administer the appropriate fluid and to regulate its quantity to rectify the persisting abnormalities in the specific gravity values.

IV *Response to Therapy*—This criterion was utilized during the administration of various fluids by the periodic reapplication of the first three criteria.

RATIONALE FOR FLUIDS USED

The main indications for the use of the five separate fluids are outlined.

1 Citrated blood (1:5 dilution, with citrate-dextrose preservative)

(a) To increase the oxygen-carrying capacity of the circulating blood in hemorrhagic "shock," posthemorrhagic anemia and postburn anemia.

(b) To spare proteins, which otherwise would be used to manufacture red cells, for other purposes.

(c) To provide essential red cell-building material for patients unable to ingest these materials (patients with abdominal injuries, facial-neck injuries and similar injuries).

(d) To combat other types of anemias.

2 Concentrated albumin (25 Gm per hundred cubic centimeters) and concentrated plasma (threefold or fourfold)

(a) To rectify oligemia rapidly, especially in the severer grades of shock, hemorrhagic or plasmorrhagic, as previously discussed.⁶

5 Hill, J. M., Muirhead, E. E., Ashworth, C. T., and Tigertt, W. D. The Use of Desiccated Plasma, with Particular Reference to Shock, *J. A. M. A.* **116**: 395-402 (Feb. 1) 1941. Muirhead, E. E., and Hill, J. M. The Advantages and Clinical Uses of Desiccated Plasma, *Ann. Int. Med.* **16**: 286-302 (Feb.) 1942. Erf, L. A., and Jones, H. W. Experiences Associated with Transfusion Unit in Seven Hundred Bed Hospital. Annual Survey of Over 3,500 Administrations of Blood and Plasma (Dried), *ibid.* **19**: 1-27 (July) 1943. Ashworth, C. T., Muirhead, E. E., and Hill, J. M. The Effect of Hypertonic Plasma on Body Fluids in Normal Experimental Animals, *Am. J. Physiol.* **136**: 194-199 (March) 1942.

(b) To replenish proteins in hypoproteinemia

3 Normal plasma (5 to 6 Gm per hundred cubic centimeters)

(a) To treat shock, but slower than the concentrated solutions in action and the administration of comparable amounts of protein

(b) To supplement dietary protein and salts

(c) To supplement salt and dextrose solutions in dehydrated and suspected dehydrated patients as per previous discussions⁶

4 Five per cent dextrose in isotonic solution of sodium chloride

(a) To supplement sugar and salt intake, usually given with thiamine hydrochloride.

(b) To replace fluid in cases in which excessive fluid loss had occurred (Wangensteen suction, restricted oral intake and other causes)

(c) In the presence of oliguria in which oligemia and major nephropathy were not directly suspected

5 Five per cent dextrose in distilled water

(a) To encourage urinary output, often alternated with isotonic solution of sodium chloride

(b) As a means of administering carbohydrate, usually given with thiamine hydrochloride

ILLUSTRATIVE CASES

The salient features of several cases are given to illustrate the foregoing discussion

The term "shock" is used to cover mainly the hemodynamic abnormalities due to oligemia and reflected by such well known signs as weak pulse, lowered blood pressure, poor filling of veins, pallor, sweating, coldness of the skin, mental confusion and dulness and oliguria

The specific gravity values were considered definitely abnormal when found to be outside previously established ranges¹ These ranges for blood were 1 0543 to 1 0619 and for serum 1 0247 to 1 0299 The blood pressure as given signified millimeters of mercury, and the pulse rate signified beats per minute

I *Hemorrhagic Group*—A Patients Seen Within Twenty-Four to Thirty-Six Hours after Injury (Shock Period) 1 With normal or near normal criteria The subsequent uneventful course in cases of this type provided justification for the discussed criteria

CASE 1—A man was seen two to three hours after injury, with a shrapnel perforation of the abdominal wall and signs of peritoneal irritation No signs of shock were apparent, the blood pressure was 120 systolic and 70 diastolic, and the specific gravities were 1 053 (whole blood) and 1 027 (serum) At operation no

6 Hill, J M, and Muirhead, E E The Use of Desiccated Plasma in Urology, *J Urol* **47** 387-394 (March) 1942 Muirhead, E E, Hill, J M, and Ashworth, C T The Use of Human Plasma Protein Solutions in Surgery, *South Surgeon* **11** 414-431 (June) 1942

CASE 11—A patient was first observed four and one-half hours after injury, with a severe compound fracture of the left humerus and lacerations of the right arm and scalp. He had received 750 cc of normal plasma prior to arrival. Specific gravity readings were 1048 (whole blood) and 1025 (serum), and he showed evidences of severe shock, coma, imperceptible pulse, pronounced pallor and grayish blue mottling of the skin, inconspicuous veins, normal cutaneous turgor and other symptoms. He was given 500 cc of concentrated albumin solution (125 Gm of albumin) within the next fifty minutes, after which his veins filled and became more available for citrated blood, which was started. One hour after administration of the albumin solution, while the blood was being given, the specific gravity readings were 1042 (whole blood) and 1026 (serum) and another hour later 1048 (whole blood) and 1026 (serum). Altogether, 3,300 cc of citrated blood was given within 68 hours of his admission. The arm was amputated during the latter part of the transfusions, about five hours after admission. He progressed well subsequently.

CASE 12—A patient was observed fourteen hours after injury, with extensive lacerations of the upper part of the left arm. The clinical picture was that of severe shock (weak pulse [rate 106], blood pressure 100 systolic and 64 diastolic, mental cloudiness and pale but dry skin). The specific gravities were 1047 (whole blood) and 1023 (serum). His history revealed that there had been no urinary output in eighteen hours, yet the bladder seemed empty. After twenty-five minutes of observation, his condition was unchanged, the values for specific gravity remained at 1047 (whole blood) and 1023 (serum). Following the administration of 1,200 cc of citrated blood and 1,000 cc of 5 per cent dextrose in isotonic solution of sodium chloride, the blood pressure was 116 systolic and 75 diastolic and the patient showed clinical improvement and subsequent normal urinary output. Four hours after infusions, the specific gravity readings were 1047 (whole blood) and 1023 (serum).

CASE 13—This report demonstrates transient hypertension in a hemorrhagic patient. He was seen three and one-half hours after injury causing extensive lacerations of the shoulder and compound fracture of the humerus. Five hundred cubic centimeters of normal plasma was given prior to his arrival. The specific gravities were 1043 (whole blood) and 1024 (serum), and he exhibited clinical signs of shock. He was given 1,000 cc of citrated blood and 1,250 cc of normal plasma, with clinical improvement to the pulse, which became strong (rate 96). The patient was mentally alert. The veins became easily accessible. During operation (debridement and other treatment) oozing of the blood occurred, the pulse rate was 108 and the blood pressure 160 systolic and 80 diastolic. During the next thirty minutes the blood pressure dropped rapidly, (120 systolic and 60 diastolic, 114 systolic and 70 diastolic and 100 systolic and 54 diastolic), the pulse became rapid (rate 150) and weak and other signs of shock appeared. The specific gravities were 1040 (whole blood) and 1025 (serum). After transfusion of 1,900 cc. of citrated blood and 600 cc. of normal plasma, signs of shock abated, later, specific gravity of the blood was 1043. The patient was transferred before the posthemorrhagic anemia was properly treated, but satisfactory recovery was reported later.

CASE 14—Originally a patient was treated for shock with plasma in the field. When seen by us, he had severe anemia and went into shock at operation. He was seen twenty-four hours after injury, with compound fractures of the right tibia and fibula and lacerations about the left shoulder. He had received 1,750 cc of plasma, shortly after injury, for "shock." On his arrival, the pulse rate

was 104, the oral temperature was 101.6 F and he was extremely weak, but the veins filled well and there were no signs of shock. The specific gravity readings were 1.038 (whole blood) and 1.024 (serum), and the right foot was cold and blue beyond the cast, twenty minutes later the specific gravities were 1.037 (whole blood) and 1.024 (serum). During the next four and one-half hours, 2,000 cc of citrated blood was given, the specific gravities eighteen hours after the blood was given were 1.0425 (whole blood) and 1.023 (serum) and eight hours later 1.042 (whole blood) and 1.023 (serum). Within the next 5.2 hours an additional 1,600 cc of blood was given. Improvement continued.

Before operation (amputation of the lower third of the right thigh) and forty-five hours after admission, the specific gravities were 1.047 (whole blood) and 1.023 (serum), the blood pressure was 130 systolic and 80 diastolic and the pulse rate 116. There were no indications of shock. During operation the blood pressure dropped to 104 systolic and 56 diastolic and the pulse weakened, the specific gravities were 1.044 (whole blood) and 1.0215 (serum), and 300 cc of concentrated albumin solution (75 Gm of albumin) was given in fifty-five minutes. After this therapy the patient showed prompt improvement, the pulse became stronger (rate 100) and other signs of shock disappeared. Five and one-half hours later, the specific gravities were 1.040 (whole blood) and 1.023 (serum) and the blood pressure was 116 systolic and 66 diastolic. Administration of citrated blood was started. After 1,100 cc of citrated blood, he showed additional improvement, with the blood pressure 128 systolic and 80 diastolic and a pulse rate of 90. Fifteen hours later the specific gravities were 1.0425 (whole blood) and 1.023 (serum), the blood pressure was 124 systolic and 78 diastolic, the pulse rate 88 and the oral temperature 99.6 F. Five and one-half hours later the specific gravities were 1.0445 (whole blood) and 1.023 (serum). During the subsequent twenty-four hours, 400 cc of concentrated plasma (threefold) and 300 cc. of concentrated albumin solution (75 Gm of albumin) were given for hypoproteinemia. The patient was progressing well at transfer, seventy-two hours after admission.

CASE 15—A patient was seen thirty minutes after injury, with a shrapnel perforation of the chest posteriorly. He was pale and gasping slightly. His veins were filled fairly well, the pulse was weak (rate 120) and the blood pressure was 88 systolic, by palpatory technic. He was observed thirty minutes later, during which time the signs were unchanged. The blood pressure was 78 systolic, and the specific gravities were 1.046 (whole blood) and 1.022 (serum). During the next two hours 1,500 cc of normal plasma was given, with clinical improvement. The blood pressure was 108 systolic, the pulse rate was 120 and the specific gravities were 1.044 (whole blood) and 1.025 (serum). Then 2,000 cc. of citrated blood was given in the next four hours, with pronounced improvement (lips pink and pulse strong [rate 110]), the blood pressure was 120 systolic and 70 diastolic and the specific gravities were 1.046 (whole blood) and 1.025 (serum). Twenty-four hours later he was resting quietly and could ingest liquid nourishment, and the specific gravities were 1.047 (whole blood) and 1.025 (serum). The final diagnosis was shrapnel perforation of the chest, with hemothorax.

B Patients Seen Thirty-Six to Forty-Eight Hours After Injury, When Anemia and Hypoproteinemia Were Prominent

CASE 16—A patient was admitted seven days after an injury causing compound fractures of both tibiae and fibulae. The cast was permeated with dried blood. The patient had received 2,000 cc. of normal plasma shortly after the

injury The specific gravities on arrival were 1032 (whole blood) and 1023 (serum) The patient was extremely weak, badly confused mentally and at times semidelirious A check of the specific gravities two hours later, when administration of blood was started, gave 1033 (whole blood) and 1023 (serum) During the next fourteen hours he was given 3,360 cc. of citrated blood (after 2,000 cc. the specific gravities rose to 1045 [whole blood] and 1023 [serum]), and four hours after the administration of blood the specific gravities were 1054 (whole blood) and 1025 (serum) Clinical improvement was outstanding The patient demanded food, was able to ingest a light diet and showed further satisfactory progress

CASE 17—A patient was injured twenty-seven days before admission He had a perforation of the abdomen, requiring colostomy, and had received a transfusion of 1,500 cc. of blood He was emaciated and on a starvation diet, with specific gravity readings of 1046 (whole blood) and 1016 (serum) He showed pronounced restlessness and had insomnia Specific gravity readings were partly masked by the chronic dehydration Two thousand four hundred cubic centimeters of citrated blood was given while the patient was observed closely He received also 100 mg of thiamine hydrochloride and 200 mg of ascorbic acid He slept well that night and appeared much stronger at the time that he was transferred.

CASE 18—A patient had sustained a fracture of the left forearm forty-eight hours before admission, 250 cc. of normal plasma had been given On admission he had evidences of gas gangrene (oral temperature was 104 F, and pulse rate was 132) and specific gravities were 10405 (whole blood) and 1023 (serum) The administration of blood was started and amputation performed He was given 3,000 cc of citrated blood in six hours Four hours after the blood was given, the specific gravity readings were 1047 (whole blood) and 1023 (serum) During the next twenty-four hours the patient was given 1,000 cc of 5 per cent dextrose in isotonic solution of sodium chloride, 750 cc. of normal plasma and 400 cc of concentrated plasma (fourfold) for dietary hypoproteinemia He was recovering satisfactorily when transferred.

CASE 19—A patient was seen nine days after injury causing multiple shrapnel lacerations of the buttocks and thighs Specific gravities were 1046 (whole blood) and 10245 (serum) Clinically he was pale, but there were no alarming signs of shock. He was given 3,600 cc of citrated blood during the next twenty-four hours, and twenty-four hours later the specific gravity readings were 1056 (whole blood) and 1025 (serum) The intake-output of water was normal, the urine was normal and the patient was recovering nicely when transferred.

The manner in which the red cell concentration (specific gravity) of the blood reached its peak after transfusion is demonstrated in 2 cases

CASE 20—A patient was seen three hours after injury causing perineal lacerations and damage to the urethra Hemorrhage was still in progress when he was admitted. The specific gravities were 1051 (whole blood) and 1024 (serum) There were no definite signs of shock (compensation was adequate) The blood pressure was 140 systolic and 80 diastolic, and the pulse rate was 120 There was definite pallor, and the veins were less prominent. Before and during operative repair, 1,800 cc of citrated blood was given, in six hours the specific gravities were 1055 (whole blood) and 1025 (serum), two hours later they were 1055

(whole blood) and 10255 (serum) and eleven hours later (nineteen hours after admission) they were 1057 (whole blood) and 1027 (serum). The patient remained well hydrated during these periods.

CASE 21—A patient showed a greater hemodilution originally. He was seen forty-eight hours after injury necessitating amputation of the left leg below the knee. The blood pressure was 140 systolic and 70 diastolic, the pulse rate was 100 and the specific gravities were 1037 (whole blood) and 1020 (serum). Within three and one-half hours, 2,400 cc of citrated blood was given, eight and one-half hours later the specific gravities were 1045 (whole blood) and 1022 (serum) and twenty-four hours beyond this 1048 (whole blood) and 10235 (serum). The patient kept well hydrated. Despite substantial transfusion, it was not sufficient to cope with the anemia completely.

A paradoxical change in the values for specific gravity was observed in rare cases in which the patients did not display evidence of hemolysis. In these instances, a substantial transfusion was followed by prominent hemodilution.

CASE 22—A patient was seen 28 hours after injury causing multiple lacerations. Clinical shock was prominent, specific gravities were 1050 (whole blood) and 1025 (serum). Within eight hours he was given 3,000 cc. of citrated blood and 500 cc of normal plasma, and six hours later the specific gravities were 1046 (whole blood) and 1022 (serum). Shock was controlled. The explanation for this is that extreme depletion of blood volume had occurred, which was only partly replenished even with a substantial transfusion. Compensatory mechanisms reflected a clinical recovery after the volume was partly replenished. Hemodilution resulted.

II *Plasmorrhagic Group*—A Normal or Near Normal Clinical Picture and Normal or Near Normal Specific Gravity Values

The patients in the plasmorrhagic group had superficial though frequently widespread burns, with no visible swelling and no particular alterations in the values for specific gravity, and a normal clinical picture. Mild or no therapy was followed by a satisfactory clinical course.

CASE 1—A patient was seen about thirty hours after receiving burns of the face, upper extremities, hands and back. All burns were superficial. There had been no previous therapy. Specific gravities were 1057 (whole blood) and 1026 (serum). No intravenous therapy was given. His progress was good.

CASE 2—A patient was seen about thirty hours after receiving a burn. There had been no previous therapy. Burns of the face, neck and both legs and hands were superficial. Specific gravities were 1056 (whole blood) and 10245 (serum). He was given 750 cc of normal plasma but no other therapy. His progress was good.

CASE 3—A patient was seen three hours after receiving burns of the face, neck, upper extremities and a small part of the chest anteriorly. No shock was present. The specific gravities were 1056 (whole blood) and 1027 (serum). He was given 500 cc of normal plasma but no other therapy. His progress was good.

CASE 4—A patient was seen eighteen hours after receiving burns of the arms, hands and face. There was no shock. Specific gravities were 1.0575 (whole blood) and 1.023 (serum). He was given 500 cc. of normal plasma and 1,000 cc. of 5 per cent dextrose in isotonic solution of sodium chloride. Thirteen hours later the specific gravities were 1.054 (whole blood) and 1.023 (serum). His progress was good.

B. Case of Severe Hemoconcentration. Early and later period. The period of shock and the subsequent period of anemia and hypoproteinemia are illustrated in this report of a case of a severely burned patient treated for ten days and followed subsequently.

H. B. was burned in an explosion aboard a landing craft. The heat was intense enough to burn all the clothing off his body, leaving all body surfaces burned except the area covered by trunks (see fig. 1). By Berkow's classifica-



Fig. 1—These figures indicate the extent of body surface burned on H. B. The exposures were taken during the latter part of the stay, when much of the swelling had subsided. The burns of the back corresponded to these anterior zones, the prominent lines of demarcation at lower trunk and upper thigh continuing on around. Swelling of the face and neck had completely subsided. (Dr. Herbert Alden, Atlanta, Ga., supplied this photograph.)

tion—80 per cent of the body surface was involved. The patient was seen two hours after the burn, when specific gravity readings were taken and treatment started.

Figure 2 shows changes in specific gravity over a period of ten days and after fluids had been given intravenously. Notice the 5,200 cc. of normal plasma (about 300 Gm. of proteins) and 585 cc. of concentrated albumin solution (146 Gm. of albumin) during the first forty-eight hours to control hemoconcentration.

7. Berkow, S. G. A Method of Estimating the Extensiveness of Lesions (Burns and Scalds) Based on Surface Area Proportions, *Arch. Surg.* 8: 138-148 (Jan.) 1924.

80 per cent of which was given during the first twenty-four hours. When values for specific gravity began dropping, they continued to do so despite the administration of 2,600 cc of citrated blood, the lowest levels, 1049 (whole blood) and 10225 (serum), occurred after transfusions. Oral intake, of the amount desired, during this time was 2,400 to 3,200 cc in twenty-four hours, and the urinary output was 1,600 to 2,800 cc. per twenty-four hours. During the last seventy-two hours, values for specific gravity returned to normal and oral intake and urinary output doubled, 6,800 to 8,200 cc and 4,000 to 5,000 cc. respectively.

The patient's injuries consisted of massive burns, mostly second degree, with extreme swelling despite moderate compression dressings. Usual high remittent temperature (oral temperature 101 to 103 F) during the first four days lowered to 99 to 100 F during the last days. Penicillin (20,000 Oxford units every three hours) was given intravenously and intramuscularly throughout. Locally unmedicated white petrolatum gauze, with moderate compression dressings, was used.

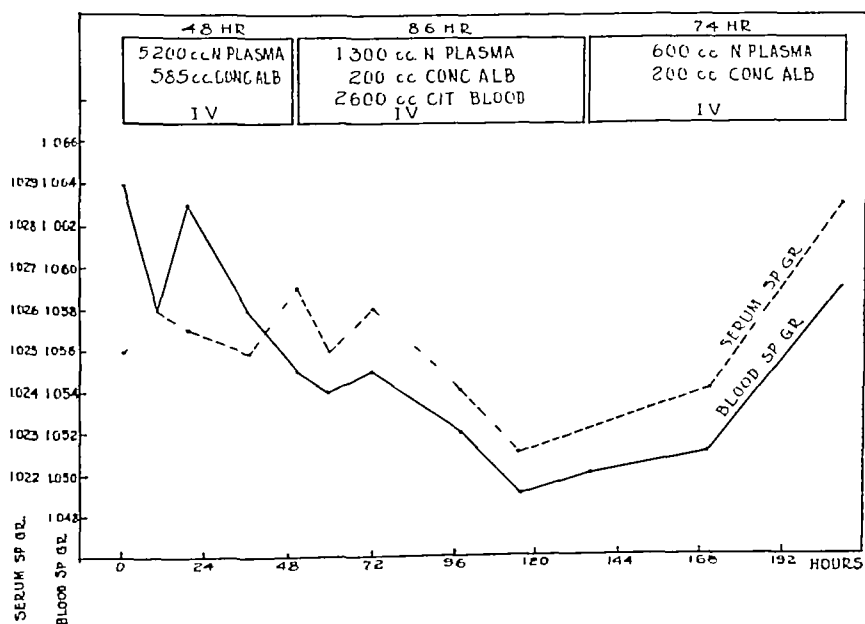


Fig 2—The specific gravity values for blood serum over a nine day period for H B, a patient in a case of burn, are given together with the fluids administered intravenously and the intervals when these were given. The patient had an 80 per cent body surface burn and recovered.

The patient was allowed free access to fluids taken orally, and thiamine hydrochloride (25 to 75 mg) and ascorbic acid (50 to 200 mg) were given daily parenterally.

With close attention given to oral dietary intake, after seventy-two hours it was possible to give the patient 150 to 200 Gm of proteins by mouth, in the form of albumin—eggs, milk, cheese and meats. Carbohydrate intake was maintained without difficulty.

Mild mental confusion and irrelevant soliloquies appeared periodically during the early phase, especially the first seventy-two hours, but at all times the patient was mentally accessible and cooperative. Swelling of the face and neck was pronounced during the first forty-eight hours in areas where no compression

dressing was used. Swelling began to disappear after sixty to seventy-two hours but still was noticeable after seventy-two hours (see fig 1).

Infection (demonstrated by usual yellowish green exudate) was limited to scattered areas. Two months later the patient was convalescing and progressing well.

COMMENT

For both hemorrhagic (lacerations and fractures) and plasmorrhagic (burns) patients, the term "shock" is used to cover the clinical signs indicative of oligemia. Prominent among these signs are a weak pulse, pallor, sweating, coldness of the skin, inconspicuous superficial veins, ashen cyanosis and lowered blood pressure. In the cases of severer injury, mental cloudiness, restlessness or coma and oliguria were present. Compensatory mechanisms at times obscured some of these signs.

It is understood that certain fundamental differences in the pathogenesis of the two types of oligemia exist,⁸ outstanding being hemodilution in hemorrhagic patients and hemoconcentration in patients with burns, yet, from the clinical view the proper treatment of the oligemia during the therapeutically amenable period, usually the early hours, ameliorated the similar signs in the two types.

The application of the four mentioned criteria afforded the best means of judging the oligemic needs for fluids during the period of shock in both types.

The extent and type of injury not only naturally segregated the two major types, i. e., the hemorrhagic and plasmorrhagic, but also was indicative of the severity of existing or potentially developing oligemia. In isolated instances a small laceration strategically placed (such as a small laceration severing the brachial artery) initiated copious hemorrhages, but in the great majority the extent of the injury paralleled the extent of blood loss. Thus, an analysis of the types and extent of injury considering the greater to the lesser degree of blood loss gave a list somewhat as follows: multiple compound fractures (especially comminuted type), single compound fracture, severe abdominal injury, severe thoracic injury, multiple lacerations, simple fracture and single laceration.

For cases of burns the extent of body surface involved was not so important as the depth of swelling of burned sites. It was, therefore, considered precarious to judge needs for protein and salt during the oligemic period by the percentage of body surface involved alone. For instance, many patients (following *kamikaze* attacks) with extensive superficial burns and little or no visible swelling had no particular elevation of specific gravity and required little or no intravenous ther-

⁸ Moon V. H. Shock: Its Dynamics, Occurrence and Management, Philadelphia, Lea & Febiger, 1942.

apy Conversely, a patient with a partial burn of one upper extremity and much swelling had severe concentration (specific gravities 1 067 [whole blood] and 1 026 [serum]) and required 400 cc of concentrated albumin solution and 1,000 cc of normal plasma to lower specific gravity values to 1 052 (whole blood) and 1 025 (serum) These observations were made in the types of cases discussed by British workers⁹

The one outstanding variable in evaluating the clinical signs of shocks (clinical picture) was the level at which compensatory mechanisms came into play This problem may be elucidated as follows Minor grades of deficit (the donor parting with 500 cc) are attended by minor or no signs of shock¹⁰ It is usually considered that losses of 1,000 cc are frequently well tolerated, though a few signs of mild shock may appear (transient weakness, giddiness, fatigue, slight tachycardia, slight sweating and other signs) Beyond 1 liter, compensatory mechanisms are apt to break down¹¹ Physiologists have emphasized that a 30 per cent acute blood loss (1,500 to 2,500 cc in average persons) is followed by prominent decompensation and signs of shock¹² The reverse of these considerations also appears practical Thus, as therapy is given, a point is reached when compensatory mechanisms come into play and obscure clinical signs, yet complete replacement may not have occurred¹³ Persistent hemodilution and persistent hemoconcentration demonstrate deficits subsequently In this series of patients, those who failed to exhibit any outstanding change from normal in the criteria used progressed satisfactorily

The main patterns observed in the hemorrhagic patients can be classified in four types First, there are the patients seen in early hours following the injury with a simple fracture of the femur or humerus or lacerations, displaying mild to moderate clinical signs of shock and normal or slightly lowered specific gravity values of blood and serum Concentrated albumin solution (150 to 300 cc), concentrated plasma (150 to 300 cc) or normal plasma (700 to 1,500 cc) given to these

9 Colebrook, L, and others Studies of Burns and Scalds (Reports of the Burns Unit, Royal Infirmary, Glasgow, 1942-43), reviewed, *J A M A* **128** 907-908 (July 21) 1945

10 Boynton, M H, and Taylor, E S Complications Arising in Donors in Mass Blood Procurement Project, *Am J M Sc* **209** 421-436 (April) 1945

11 McMichael, J Clinical Aspects of Shock *J A M A* **124** 275-281 (Jan 29) 1944

12 Macleod, J J R Macleod's Physiology in Modern Medicine, edited by P Bard, ed 9 St Louis C V Mosby Company 1941, pp 518-521

13 For instance, Maglader, Solandt and Best in an experimental study observed that a 40 per cent replacement in hemorrhages effected recovery Maglader, J W Solandt D Y, and Best, C H Serum and Plasma in Treatment of Haemorrhage in Experimental Animals *Brit M J* **2** 248-250 (Aug 24) 1940

patients diminishes the clinical signs of shock, and the specific gravity of the blood drops below normal limits. Many such patients continue on the road to recovery, manufacturing their own red cells for replacement, especially if the injuries are uncomplicated by infection or starvation. Second, there are similar patients, whose specific gravities continue to drop to lower levels (1.044 [whole blood] and 1.024 [serum]). Blood transfusions are helpful here but may not be absolutely required unless other complications exist. However, one would not hesitate in giving blood to these patients if it is readily available. Third, there are the patients with compound fractures and/or multiple lacerations, exhibiting pronounced signs of shock. The patients require greater quantities of protein solutions (400 to 500 cc. of concentrated albumin or 2,000 cc. of normal plasma). The specific gravity of the blood drops rapidly to 1.040 or lower, and at this point blood transfusion (1,200 to 3,000 cc.) are required. In most of these patients, when blood is not given severe anemia develops. Fourth, patients with severe injuries, as comminuted fractures or mangled extremities, severe abdominal wounds or thoracic wounds, clinical signs of severe shock (coma, imperceptible pulse and veins, low blood pressure, pallor and other symptoms) and specific gravity values lowered, though the injury has recently occurred, or specific gravities of the blood that drop rapidly after protein solutions, require heroic measures. Three hundred to 600 cc. of concentrated protein solutions and 2,400 to 3,500 cc. of citrated blood give the best results. The volume depletion in these cases was frequently amazing and so long as the criteria used indicated a favorable trend and venous engorgement and pulmonary rales did not develop the administration of these two fluids (or similar types) was continued. The excellent results obtained in treating these severely injured and moribund casualties justified the procedure used.

The main criterion used as a therapeutic guide for cases of burns during the shock period was the specific gravity value of blood and serum. An attempt was made at all times to control hemoconcentration, regardless of the volumes of concentrated and normal protein-salt solutions required. This technic appeared successful even in cases of severe injury.

Usually, concentrated albumin solution and normal plasma were given rapidly to the patients with burns until the specific gravity of the blood or hemoglobin concentration became normal (for specific gravity around 1.058). The infusion was then continued slowly for one hour and the specific gravity rechecked. When hemoconcentration reappeared additional protein-salt was given. This process was continued until hemoconcentration failed to develop. The main bulk of protein solution was always given the first twenty-four hours. After forty-eight

to seventy-two hours, the period of anemia and hypoproteinemia appeared

Following the period of shock there were four primary conditions which were at all times considered (1) developing anemia, (2) hypoproteinemia, (3) maintenance of adequate water-salt intake and urinary output and (4) food supplements (protein, carbohydrate and vitamins) by vein to supply metabolic needs and prevent body wastage

Anemia was at times severe. In such cases larger transfusions seemed beneficial and were given, without circulatory volume complications. Hypoproteinemia seemed controlled better when treated at the same time as the anemia

CONCLUSIONS

1 Of 5,000 battle casualties handled by a front line medical activity, 345 were closely observed and especially studied for needs for parenteral administration of fluid. The application of four criteria (clinical picture, blood pressure, specific gravities of blood and serum and the response to therapy) seemed to afford the best means of judging these needs

2 All patients could be divided into two groups (1) those with loss of blood (hemorrhagic) and (2) those with loss of plasma (plasmorrhagic)

Group 1 included patients with fractures, various lacerations and practically all types of battle injuries. Group 2 included patients with burns

3 Patients in both groups subsequently tended to display anemia and hypoproteinemia, particularly (1) when insufficiently treated early with the proper fluids given parenterally, (2) when infections developed or (3) when on a starvation diet

4 The criteria were particularly useful during the earlier hours following the injury, when "shock" was more apt to occur. In both groups "shock" was used as a means of identifying oligemia (blood loss oligemia and plasma loss oligemia) and was considered to exist when well known signs persisted. The main signs used were a weak pulse, inconspicuous superficial veins, cyanosis and lowered blood pressure, coldness, pallor, sweating, mental signs, oliguria and deviation from normal specific gravity values for blood and serum

5 The proper replenishment of the blood volume as judged by the improvement in the criteria mentioned nullified the signs of shock in both groups

6 Citrated blood was an essential fluid for both groups and was indispensable for the hemorrhagic patients. Concentrated protein solutions (albumin and plasma) were most effective in coping with oligemia so long as the cutaneous turgor was normal or near normal. These con-

centrated solutions were of particular value in the severer grade of shock and in burns

7 The specific gravity values determined by the copper sulfate method were extremely useful and most practical for a quick and dependable therapeutic guide

8 Frequently, large infusions (what have been termed massive) were required to cope with the fluid losses. It was clearly observed that in cases in which the need was great the larger volumes were not just beneficial but essential. Venous engorgement and pulmonary rales, the outstanding signs of a circulatory overload, were not observed in these patients. This is probably due to the fact that all casualties treated had suffered severe fluid losses and the massive infusions and transfusions were replacements for those fluid losses.

9 During the period beyond the shock interval, the use of the specific gravity values and the application of established principles (dietary intake, urinary output, clinical response to treatment and other factors) became more important in the decision on needs for fluid. More elaborate procedures were not available.

10 The copper sulfate specific gravity method for determining the hemoglobin concentration and plasma protein values was of inestimable value in the proper treatment of battle casualties. The method is so simple that it can be used under combat conditions, and when added to the clinical observations noted as criteria for evaluating shock, fluid therapy and dietary requirements provides much of the data necessary for the intelligent handling of casualties in the early phases of a military operation, when more elaborate facilities are not available.

PULSATING BENIGN GIANT CELL TUMORS OF BONE

Report of a Case and Review of the Literature

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AND

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PHILADELPHIA

PULSATING tumors of bone present unusual difficulties both in differential diagnosis and in treatment. This applies particularly to the so-called pulsating benign giant cell tumor because of its resemblance to highly malignant tumors and its constant threat of malignant transformation. The surprisingly few reported cases warrant the accumulation of all the available data in order to obtain more information concerning the nature of this lesion and its proper treatment. For this reason, an additional case is reported in detail and the literature is reviewed.

REPORT OF A CASE

M. S., a white youth aged 20, was admitted to the surgical "A" service of the Jefferson Medical College Hospital Aug. 12, 1942, with the chief complaint of a lump just below the left knee.

In April 1942, while working, the patient sprained his left ankle but received no injury to the knee. The pain disappeared after one month, after treatment by strapping and infra-red light. About two weeks after the injury to the ankle, however, he experienced a dull, nagging, constant ache at the upper end of the left tibia. This was not severe enough to cause loss of sleep. The discomfort persisted until July 1942, at which time he noticed one day that his leg was extremely and diffusely swollen from the knee down to the ankle. This condition was treated with rest in bed and hot compresses for one week, after which the diffuse swelling and pain subsided, but a hard, nontender lump persisted on the anterolateral aspect of the leg, just below the knee. This remained essentially the same size until the patient was admitted to the hospital. There was no loss of weight, and his general health was otherwise excellent.

The past medical history was uneventful, and the family history failed to reveal any member's ever suffering from similar complaints.

Physical Examination—The patient was a well developed, well nourished Jewish youth. The significant physical findings were confined to the left lower extremity. A mass about 7 by 5 cm. was visible on the anterolateral aspect of the upper end of the left tibia. The mass was hard, nodular and nontender and was fixed to the underlying bone. It was not sharply demarcated, and the overlying skin was freely movable. No pulsation was felt at this time. There was slight enlargement of the inguinal lymph nodes bilaterally.

From the Samuel D. Gross Surgical Division of the Jefferson Medical College Hospital.

Laboratory Data—The blood count revealed the hemoglobin to be 88 per cent, red cells 4,160,000 and white cells 8,000, and the differential count was normal. Results of repeated urine tests were normal. The blood Wassermann and Kahn reactions were negative. The serum calcium was 11 mg, phosphorus 4.4 mg and phosphatase 14 Bodansky units. Roentgen ray examination of the left tibia revealed the presence of a typical benign giant cell tumor at the proximal extremity (fig 1 A). The other long bones, spine, pelvis and chest were normal.

It was the opinion of the radiology department that in this case surgical intervention was preferable to roentgen therapy. Accordingly, operation was performed, with the patient under spinal anesthesia, on August 24.

Operation—The left lower extremity was prepared and a tourniquet applied loosely around the thigh, to be tightened if necessary to control bleeding. A longitudinal incision 3 inches (7.6 cm) in length was made over the antero-lateral aspect of the mass. The anterior wall of bone, which was no more than

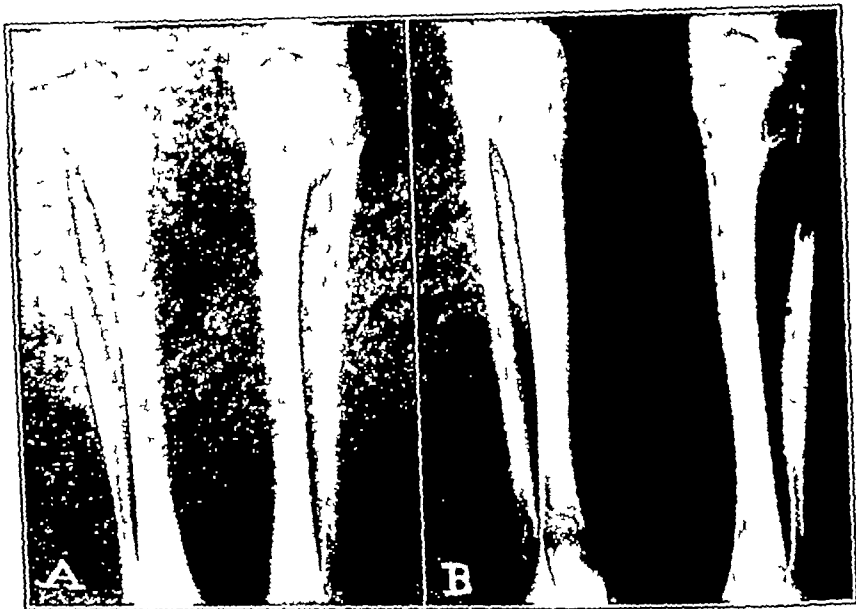


Fig 1—Roentgenograms showing benign giant cell tumor at proximal extremity of left tibia. In A, the lesion is shown preoperatively. The corresponding view of the right tibia is normal. In B, the lesion twenty-two months postoperatively shows an increase in extent despite surgical and radiation therapy.

$\frac{1}{16}$ inch (4.8 cm) thick, was chiseled away. The underlying tumor consisted of dark brown gelatinous material and was seen to pulsate vigorously with each heart beat. Curettement was performed, accompanied with much troublesome bleeding, which required tightening of the tourniquet from time to time for control. Posteriorly, in which area the tumor was in close relationship with the popliteal artery, there was no bony shell. At this site pronounced bleeding was suddenly encountered, and it could be controlled only by the tightening of the tourniquet. For this reason, further curettement had to be abandoned and the advisability of amputation above the knee was considered. A decision was made to attempt to save the limb, and, with the tourniquet still applied, 8 Gm of sulfanilamide were placed in the cavity, which was packed tightly with iodo-

form gauze. The cavity had a capacity of about 80 cc. On release of the tourniquet, no further bleeding was encountered. A plaster posterior molded splint was applied to the extremity. The patient left the operating room in good condition, with the tourniquet applied loosely around the thigh, in readiness to be tightened should severe bleeding be encountered subsequently.

Pathologic Report—The pathologic report was benign giant cell tumor of the bone (fig. 6-1).

Postoperative Course—The immediate convalescence was uneventful except for anemia (hemoglobin 65 per cent and red cells 3,500,000) which was treated by multiple blood transfusions and ferrous sulfate. Sulfadiazine was administered until the sixteenth day, with a blood level maintained between 5 and 8 mg. On the seventh day the pack was removed in the operating room with the patient under spinal anesthesia, because of the danger of further hemorrhage. Sulfamidamide crystals (8 Gm.) were placed in the cavity and the wound was again packed with iodoform gauze. Subsequently the wound was treated with sulfamidamide irrigations and iodoform packs. At no time did the wound become infected. Roentgen ray examination on the thirty-fourth day revealed that curettement had been incomplete and deep roentgen therapy was advised by the radiology department. This was started on the forty-second day and a total of 2,024 r was given to the anterior and posterior fields over a period of eleven days. Serial roentgenograms showed a gradual filling in of the bony defect, but extensive mottling of the lateral portion of the head of the tibia persisted strongly suggesting residual giant cell tumor. The patient was discharged to the care of his family physician on Jan. 30, 1943, five months and six days after operation. At this time there was still a cavity in the wound with a volume of about 20 cc. A caliper brace was prescribed by the orthopedic department, permitting walking without weight bearing on the knee.

Second Admission—The patient was referred for readmission by his family physician on March 9, 1943, because of excessive bleeding and pulsation of the wound noted during the preceding two weeks. Blood count, urine, serum calcium, phosphorus and phosphatase were normal. Roentgen ray examination revealed no significant changes in the appearance of the tumor area. The remainder of the bony skeleton and the lung fields were normal. A second course of roentgen therapy, consisting in 2,131 r, was given to anterior and posterior fields over a period of ten days, following which the wound healed and the pulsation ceased. The patient was discharged on April 3, 1943, to the further care of his family physician and to the follow-up care of the tumor clinic. Use of the walking caliper was continued.

Third Admission—The patient was referred for readmission by the tumor clinic on June 12, 1944, because of roentgen ray evidence that the tumor was again increasing in size. His general health had remained excellent, there was no loss of weight and walking had been satisfactory with the aid of the caliper brace.

Physical examination revealed a mass about 2 cm in diameter in the operative scar, near its upper pole (fig. 2). The mass was nontender, smooth, semifluctuant and adherent to the overlying skin, which was atrophic and of a purplish color. It had an expansile pulsation, a slight thrill and a soft systolic bruit, all of which could be abolished by compression of the femoral artery in the groin. The bruit was audible around the entire circumference of the leg, just below the knee, but was most noticeable anteriorly, in the area of the scar, and also posteri-

only, over the popliteal vessels. The dorsalis pedis and posterior tibial pulses were easily felt and equal on both sides. The oscillometric readings were normal for the legs and feet. Aspiration of the mass in the scar readily yielded 5 cc of blood, which clotted promptly.

The blood count and blood chemistry studies again gave normal results. Roentgen ray examination revealed that the tumor had again increased somewhat in size since the previous examination (fig 1 B). Roentgenograms of the pelvis, spine, skull and chest showed no evidence of metastatic lesions.

Because of the unusual physical findings already described, it was thought that a false aneurysm might have resulted from the trauma of the first operation or

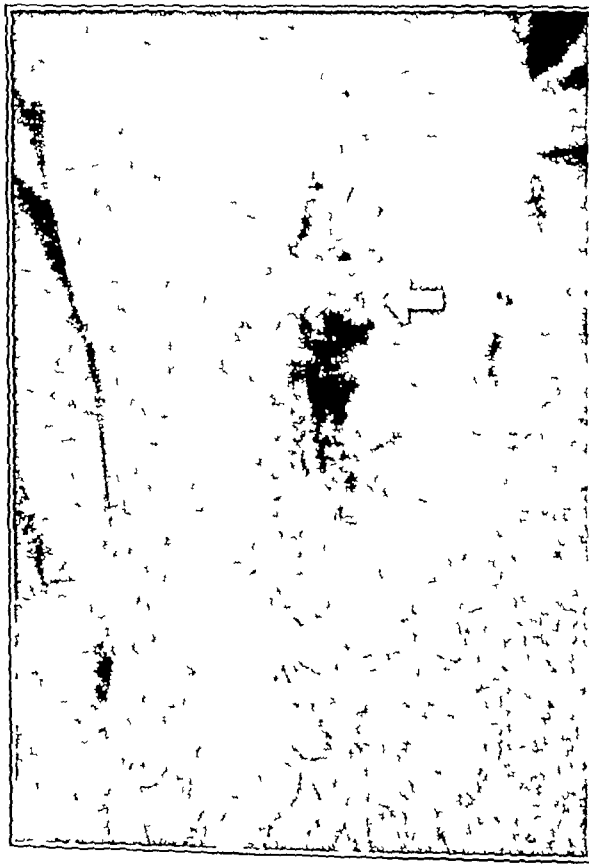


Fig 2—Expansile pulsating mass, indicated by arrow, in the scar twenty-two months following operation.

that there might possibly have been transformation into a malignant bone aneurysm. Arteriography, diodrast being used as contrast material, revealed the presence of many new, smaller vessels around the area of the tumor but no evidence of aneurysm (fig 3). Venography revealed a normal venous circulation, with a well visualized deep vein running in the popliteal space (fig 4). Few venous channels were seen in the tumor. Biopsy of one of the left inguinal nodes revealed no evidence of tumor involvement.

A third course of deep roentgen therapy consisting of 1,000 r spread out over a period of twelve days, was administered to the anterior and posterior fields. The total dose of the three series was 5,155 r (200 kilovolts, 0.5 mm of copper and 1 mm of aluminum).

Because the lesion was progressing despite both surgical and roentgen ray therapy and because of the pronounced vascularity associated with physical signs of bone aneurysm, suggesting the possibility of malignant transformation, either potential or actual, it was deemed advisable to amputate above the knee. Conse-



Fig 3—Arteriogram showing many new smaller vessels around the area of the tumor

quently, mid thigh amputation with the patient under spinal anesthesia, was performed June 28, 1944.

Convalescence was uneventful, and the patient was discharged as well on July 31.

Pathologic Examination (by Dr Peter A Herbut)—Gross Examination The specimen is a left lower extremity that has been amputated

in the middle third of the thigh. Approximately 5 cm below the knee, there is an anteriorly placed, well healed, old operative incision. This extends for approximately 7.5 cm distally. At this place and laterally, there is a fluctuant soft tissue mass that produces slight bulging of the cutaneous surfaces. Just beneath the previous incision of the skin there is a small area, measuring 2.5 by 2 cm, where soft, dark, beefy red



Fig 4—Venogram showing patency of the deep veins in the area of the tumor

tumor tissue has broken through the deep fascia (fig 5 a). The skin has not been penetrated. Dissection of the soft parts elsewhere reveals tumor tissue bulging from the head of the tibia into the surrounding muscle and fascia. The tumor tissue is limited by the overlying deep fascia. Posteriorly, a small mass of red and gray tumor tissue, measuring 2.5 by 3 cm, bulges out into the joint space between the tibial condyles (fig 5 b). The cartilaginous surfaces are smooth and have

not been eroded. A coronal hemisection of the tumor mass and tibia reveals a tumor mass arising from the head of the tibia (fig 5c). Nearly the entire head of the tibia is replaced with soft fleshy tumor tissue. The surfaces are mottled—dark red, reddish gray and yellowish gray. The central portion is especially soft and hemorrhagic. The entire tumor mass measures 8 by 6 by 6 cm in greatest diameters. Superiorly, tumor tissue lies immediately beneath the cortical bony layer of the knee joint. Both laterally and posteriorly the tumor has broken through and completely destroyed the cortical bone. Here, as previously described, tumor tissue is invading the surrounding musculature and soft tissues (fig 5d). Both medially and anteriorly the cortex of the tibia is intact, and 1.5 to 2 cm of cancellous bone has not been invaded. Dissection

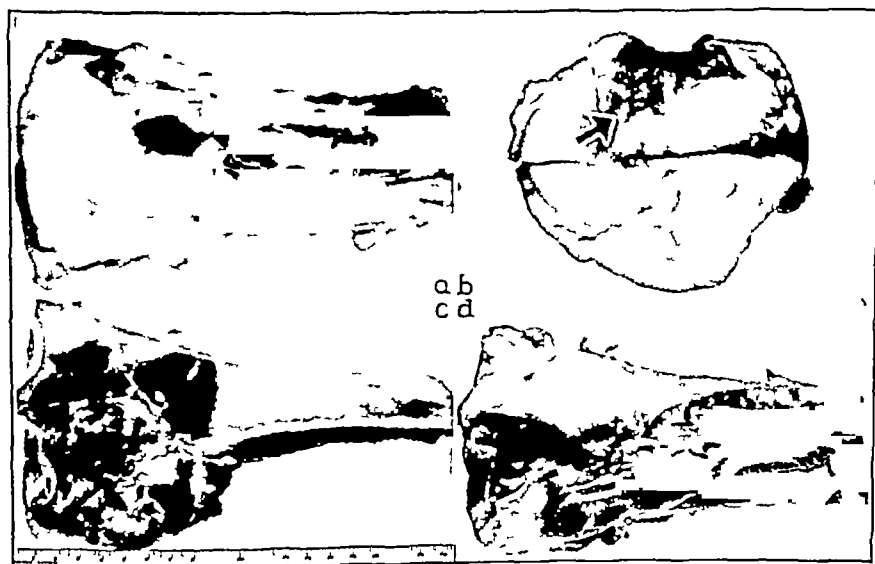
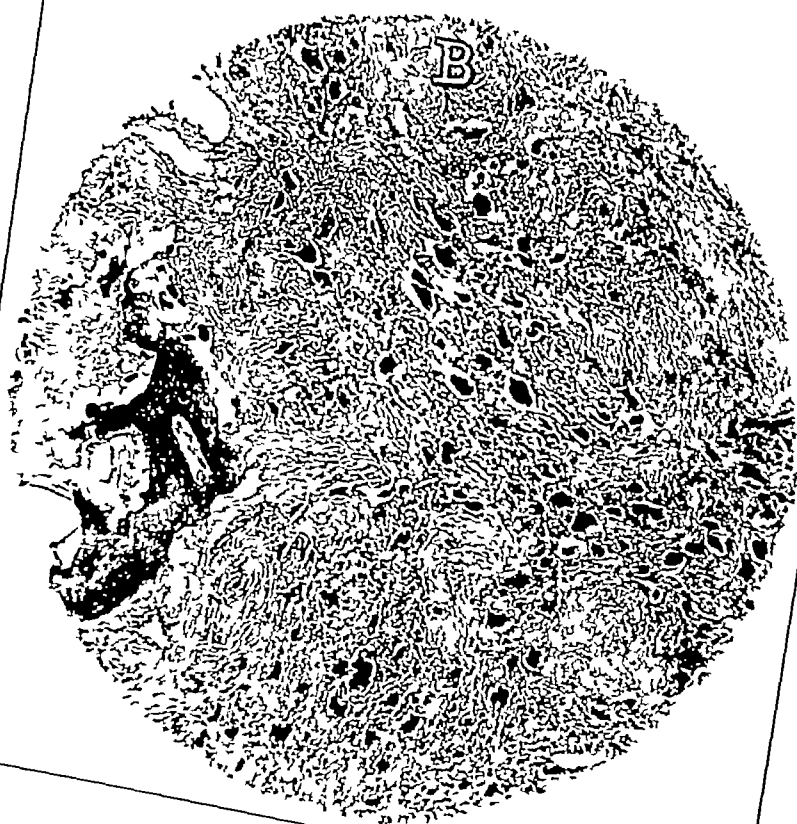
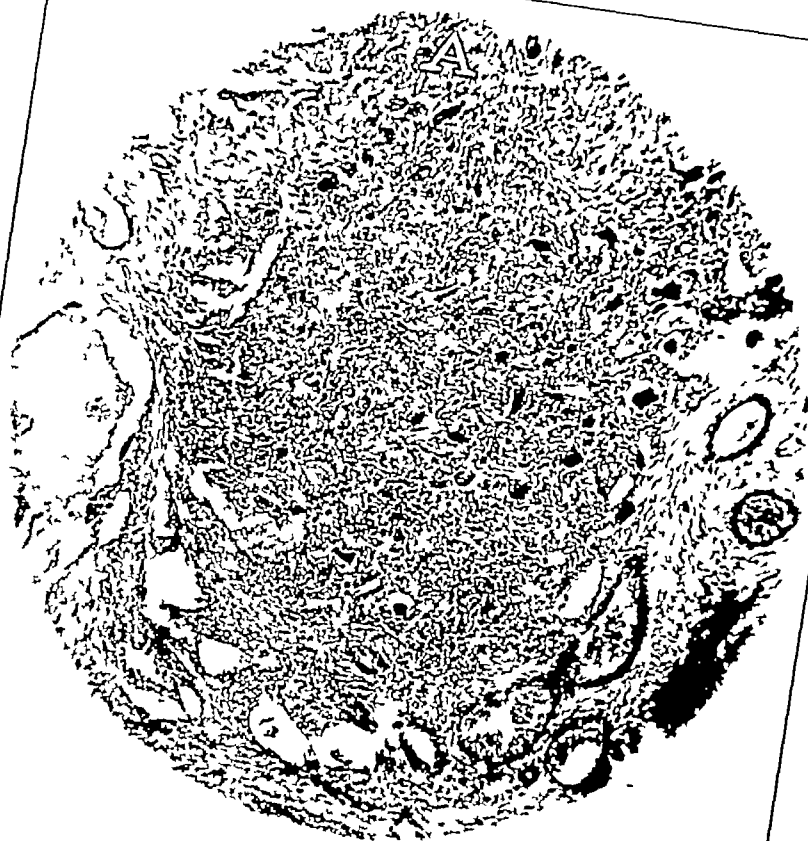


Fig 5—Gross specimen (a) protrusion of tumor, indicated by arrow, anteriorly through deep fascia in area corresponding to figure 2, (b) tumor tissue, indicated by arrow, between the tibial condyles posteriorly, (c) coronal hemisection of proximal end of tibia, showing replacement of most of head by tumor, (d) posterior aspect, showing invasion of surrounding musculature.

of the popliteal, posterior tibial and peroneal arteries reveals no large vascular connections with the tumor mass. The vessels posteriorly lie on the deep fascia covering the tumor. There are no aneurysms or vascular anomalies. Further dissection of the tibial shaft reveals that the tumor is limited to the head and upper 3 cm of the shaft. In the popliteal space there are two discrete reddish gray lymph nodes.

Histologic Examination. More than forty sections of the tumor were examined. They are all essentially similar and consist of two elements in varying proportions (fig 6B). The stroma is composed of



(See legend on opposite page)

connective tissue which in most sections is rather loose and cellular. The cells are relatively large. Their cytoplasm is abundant and elongated but the borders are not sharp and they often blend with adjacent cells. The nuclei are mostly oblong or spindle shaped. Only occasionally are they round. They are however regular and evenly stained and show no hyperchromatism or mitosis. In other sections, there is a gradation from this cellular connective tissue to rather dense fibrous tissue. This consists in intertwining bundles of rather acellular tissue, in which the cytoplasm is denser and deeply stained. Occasionally there are present small islands of cartilage and/or bone. These however, are adult in type and appear to represent inclusions rather than an integral part of the tumor. All sections are relatively avascular. The scattered capillaries are thin walled and engorged with blood. Occasionally there are foci of necrosis in the stroma.

The second conspicuous element in all the sections is the great number of giant cells of the epulis type. They vary somewhat in size, but all contain an abundant amount of deeply pink-staining cytoplasm and few to many centrally placed, round or oval, evenly stained nuclei. The sections taken from the periphery disclose a rim of dense fibrous tissue. Occasionally this contains a few spicules of adult bone and cartilage. None of the sections disclose evidence of malignant change.

Sections of the popliteal lymph nodes do not disclose any tumor involvement.

Pathologic Diagnosis—The pathologic diagnosis was benign giant cell tumor.

Follow-Up—When last seen, on April 23, 1945, two years and eight months after the first operation and ten months following amputation, the patient was in excellent health, he had gained 30 pounds (13.6 Kg), the stump was well healed, and walking was satisfactory with the aid of a prosthesis. At this time roentgen ray examination of the long bones, pelvis, spine, skull and chest showed no evidence of metastatic lesions.

COMMENT

During the past twenty years 17 cases of giant cell tumor of bone have been encountered at the Jefferson Medical College Hospital, and in this group the case being reported is the only one in which pulsation

EXPLANATION OF FIGURE 6

Photomicrographs of pulsating benign giant cell tumor. *A*, specimen obtained by curettement at first operation. Note the dilated vascular channels. *B*, specimen obtained following mid thigh amputation twenty-two months later ($\times 75$).

was noted¹ From the fact that only 7 cases, including ours, of pulsating benign giant cell tumor have been described in the literature since 1900 (table 1), one gains the impression that the lesion is exceedingly rare Jaffe² stated that he encountered no aneurysmal or telangiectatic condition in his own material from giant cell tumors Ewing,³ on the other hand, referred to this lesion as "not much described in the literature, but not at all infrequent" Nove-Josserand and Tavernier,⁴ in their book on tumors of the bone, stated that such forms are rather

TABLE 1—Summary of Cases of Pulsating Benign Giant Cell Tumor

No	Author	Year	Sex Age, Trauma	Location	Treatment	Result
1	Bloodgood J C Bull Johns Hopkins Hosp 14 134 1903 Ann Surg 69 345 1919	1903	M 26 +	Lower part of radius	Amputation of fore arm below elbow	Well 25 yr later
2	Bloodgood J C Bull Johns Hopkins Hosp 14 14, 1903 Ann Surg 56 210 1912	1903	F 45 —	Lower part of ulna	Resection of lower end of radius, ulna and first row of carpal bones	Well 15 yr later
3	Morton J J and Duffy W C Arch Surg 7 469 1923	1923	M 30 +	Upper part of tibia	Mid thigh amputation	Well 14 yr later
4	Lewis D (Cush ing's case) J A M A 83 1224 1924	1924	M 16 +	Lumbar portion of spine	Partial removal and subsequent roentgen therapy	Well 7 yr later
5	Mider G B and Morton J J Ann Surg 109 126 1939	1939	F 52 —	Ilium	Roentgen therapy followed by 6 partial excisions, ligation of internal iliac artery and application of radium	Death 1 yr after first operation, from rapidly progressing intracranial lesion associated with signs of infection
6	Scott *	1942	F 24 —	Second metatarsal bone	Roentgen therapy (2 series)	Well 10 mo later, swelling subsided and pulsation ceased
7	Shallow and Wagner	1944	M 19 ?	Upper part of tibia	Curettage followed by roentgen therapy subsequent mid thigh amputation 22 mo later	Well 10 mo following amputation

* Pathologic diagnosis made by aspiration biopsy

frequent in France and that they have observed several of them They mentioned the cases of Rougthon, Borst, Luecke and Schleich but did not give references in the literature for them

1 Shallow, T A, Raker, N, and Fry, K Primary Malignant Tumors of Bone with Special Reference to Osteogenic Sarcoma, J Internat. Coll Surgeons 6 89, 1943

2 Jaffe, H L, Lichtenstein, L, and Portis, R. B Giant Cell Tumor of Bone, Arch Path 30 993 (Nov) 1940

3 Ewing, J., in discussion on Peirce, C B Giant-Cell Bone Tumor, Am J Roentgenol 28 167, 1932

4 Nove-Josserand, G, and Tavernier, L Tumeurs malignes des os, Paris, Gaston Doin, 1927, p 104

The lesion represents a benign giant cell tumor which apparently as the result of free communication with large blood vessels, grows to large size pulsates and occasionally yields a bruit. Because the physical signs simulate those of true arterial aneurysm, the lesion has been regarded as a form of so-called bone aneurysm, a term that has been applied to pulsating, extremely vascular tumors of the bone. Ewing⁵ referred to the lesion as "aneurysmal giant cell tumor" and classified it among the benign "bone aneurysms." Although the comparatively rapid growth and large size of the tumor create the suspicion of a malignant process the benign character is demonstrated clinically by the long survival period and histologically by the absence of hyperchromatism, mitosis or the features of osteogenic sarcoma.

In the histologic picture alone, there is nothing which definitely differentiates the benign giant cell tumor which pulsates from the one in which this unusual clinical manifestation is absent. A tumor which appears extremely vascular histologically may lack pulsation clinically, while on the other hand a much less vascular one may exhibit this phenomenon to a pronounced degree. Indeed all the histologic sections in our case at the time of amputation when pulsation was most pronounced were relatively avascular (fig. 6B). Thus pulsation depends primarily on the richness of arteriolar and arterial connections and not on the richness of the capillary network. It is natural to suppose that an extremely vascular tumor might be pulsatile, but an abundant capillary network poorly connected would not show pulsation.

Scott⁶ emphasized the importance of the "tissue factors" in the pulsation sign. This term refers to a looseness and delicacy of the supportive stroma. Thus, the bone marrow normally pulsates, since the influx and reflux of blood in the thin-walled capillaries transmits the pulsation to the delicate and loose cellular tissue of the bone marrow. Scott⁶ attributed the great tendency of secondary tumors of the thyroid and kidney to exhibit pulsation to this factor as well as the extreme vascularity.

Early observers were of the opinion that bone aneurysms were true aneurysms. While these tumors may present the physical signs of true arterial aneurysms, their causation and pathogenesis have little in common with that condition. They arise as neoplasms (primary sarcomas, metastatic tumors, hemangiomas or giant cell tumors),

5 Ewing, J. *Neoplastic Diseases*, ed. 4, Philadelphia, W. B. Saunders Company, 1940.

6 Scott, R. K. Three Pulsating Tumors: Osseous Secondary from a Latent Carcinoma of the Kidney, Soft Tissue Secondary from a Latent Carcinoma of the Prostate, Benign Giant Cell Tumor of a Metatarsal Bone, *Roy Melbourne Hosp. Clin. Rep.* **13** 76, 1942.

with dilated capillaries forming blood sinuses in free communication with their arterial supply in a poorly supportive stroma, such that the walls are easily distended by the pressure of each influx of blood. When the tumor erodes through the cortex, the pulsation may be detected clinically and the term "bone aneurysm" applied. However, the old claim of these lesions to separate classification has been disregarded, and at present the term has been almost universally abandoned.

The pulsation may vary in degree from such an extent that it raises the skin and is easily perceived by the eye to being so faint that it is palpable only by carefully regulated pressure with the pulp of the fingers. In cases with energetic pulsation a systolic bruit is usually present but a thrill seldom. The degree of pulsation will not establish the presence or absence of a malignant growth, but the existence of pulsation must be construed as an ominous sign.

The differential diagnosis of pulsating tumors of bone may in some instances be exceedingly difficult. Careful correlation of clinical roentgenologic and pathologic data is required (table 2).

Telangiectatic osteogenic sarcoma, referred to by Ewing⁵ as "malignant bone aneurysm," usually occurs in young persons, grows rapidly, promptly destroys the shaft, leading to pathologic fracture, and as a rule terminates fatally, with metastasis, within a few months.

Pulsating metastatic carcinomas in bone are usually of thyroid or renal origin. Crile⁷ (1936) collected from the literature 10 histologically verified cases of pulsating neoplasms of the sternum, of which five lesions were metastatic from hypernephroma and five from malignant adenoma of the thyroid. To these he added 5 proved cases from the Cleveland clinic, one of the lesions being metastatic from a hypernephroma and four from malignant thyroid adenoma. Alessandri⁸ (1926) reported 4 cases of bone metastasis from hypernephroma, in 3 of which the neoplasms pulsated. In a review of the literature, he found that out of ninety-two such metastatic lesions twenty-seven were either of the pulsating type or of the highly vascularized type.

Hemangiomatous tumors of bone occasionally may pulsate. The malignant variety, hemangioendothelioma, is rare. Ewing⁵ stated that he has seen 3 such cases, but Stout,⁹ after reviewing the histologic description and illustration, cast doubt on their authenticity and expressed the opinion that they probably represented cases of metastases from hypernephroid carcinoma. Stout⁹ has reported 2 cases of

7 Crile, G., Jr. Pulsating Tumors of the Sternum, *Ann Surg* **103** 199, 1936.

8 Alessandri, R. Sui tumori pulsanti dell' osse ed in modo speciale sulle metastasi di ipernefroidi nello scheletro, *Polichnico (sez. chir.)* **33** 273, 1926, abstracted, *Cancer Rev* **2** 213, 1927.

9 Stout, A. P. Hemangio-Endothelioma. A Tumor of Blood Vessels Featuring Vascular Endothelial Cells, *Ann Surg* **118** 445, 1943.

TABLE 2—*Clinical, Roentgenologic and Pathologic Features in Differential Diagnosis of Pulsating Tumors of Bone*

Features	Osteogenic Sarcoma (Telangiectatic)			
	Children and young adults	Adults and elderly persons	Angioendothelioma	Metastatic Carcinoma
Clinical				
Typical age group	Children and young adults	Adults and elderly persons	Adults and elderly persons	Young adults
Common locations	Femur, tibia, humerus, pelvis and fibula	Long bones	Long bones	Femur, tibia, radius, humerus, maxilla and vertebrae
Multiplicity	Single	Occasional	Occasional	Rare
Rate of growth	Very rapid	May be rapid or slow	May be rapid or slow	Usually slow
Roentgenologic	Erosion of shaft, often with radiating lines into subperiosteal area; periosteum elevated, medullary region usually shows some condensation	Destructive lesion, with widening of bones and fine irregular trabeculation	Cortical destruction with no new bone formation or periosteal proliferation	Expanding trabeculated, destructive lesion with preservation of bony shell and multicystic appearance
Pathologic				
Origin	Primary	Primary or metastatic	Metastatic (usually from kidney or thyroid)	Primary
Character	Malignant	Malignant	Malignant	Usually benign
Histology	Pleomorphic osteoblasts in a mixed intercellular substance (hyaline, cartilaginous, myxomatous, osteoid or osseous), giant cells often present	Anastomosing vascular channels lined by heaped up, atypical endothelial cells in a fibrous tissue stroma	Hypernephroma (large clear cells in vascular scanty stroma) or malignant thyroid adenoma (resembling normal thyroid)	Giant cells in a stroma of spindle shaped and round cells
				Vascular elements (capillaries or cavernous spaces) in a fibrous tissue stroma

hemangioendothelioma of bone, but no mention is made of pulsation. He stated the belief that the diagnosis can be made with certainty only if two features are demonstrated: first, the formation of atypical endothelial cells in greater numbers than are required to line the vessels with a simple endothelial membrane and, second, the formation of vascular tubes, with a delicate framework of reticulin fibers and a pronounced tendency for their lumens to anastomose.

Bucy and Capp,¹⁰ in their review of hemangioma of bone, collected 3 cases from the literature in which pulsation was noted. Two tumors occurred in the skull (Schone¹¹ and Zajackowski¹²) and one in the clavicle (Mauguiere¹³). In these tumors there was an area of bony hardness at the periphery, raised above the level of surrounding bone, while the center was soft and pulsating.

If a true aneurysm develops in one of the branches of a main arterial trunk near the bone, it may cause a partial erosion and destruction of the bone. In such a case (Gaudier¹⁴), the roentgenologic appearance may resemble that of a tumor. Arteriography aids in distinguishing between true aneurysm and pulsating tumor of the bone. In addition, arteriography has been advocated by Inclan¹⁵ for the early diagnosis of malignant growths of bone. The most characteristic arteriographic sign of malignant growths of bone is the filling in of the stroma of the new growth with numerous vessels, forming an erratic network and showing the extension of the invading tumor. This procedure may thus be of aid in the differentiation between benign and malignant bone tumors and may avoid the necessity of specimen and punch biopsy, which has been claimed to spread tumor cells into the venous circulation by rupturing these structures. Arteriography is not without danger, however, and the possible complications have recently been reviewed by one of us.¹⁶

Diagnosis of the benign nature of a pulsating giant cell tumor is not only difficult but also dangerous from the standpoint of treatment.

10 Bucy, P. C., and Capp, C. S. Primary Hemangioma of Bone, *Am J Roentgenol* **23** 1, 1930.

11 Schone, G. Ueber einen Fall von myelogenem Hämangiom des Os occipitale, *Beitr z path Anat u z allg Path (supp)* **7** 685, 1905.

12 Zajackowski, A. Ein Fall von Angioma cavernosum des Stirnbeines, *Przeg chir* **4** 606, 1900, abstracted, *Centralbl f Chir* **28** 507, 1901.

13 Mauguier, L. Angiosarcome de la clavicule, *J de radiol et d'electrol* **4** 269, 1920.

14 Gaudier, cited by Nove-Josserand and Tavernier,⁴ p 272.

15 Inclan, A. The Possibilities of the Roentgenographic Study of the Arterial Circulation in the Early Diagnosis of Bone Malignancy, *J Bone & Joint Surg* **24** 259, 1942.

16 Wagner, F. B., Jr. Complications Following Arteriography of Peripheral Vessels, *J A M A* **125** 958 (Aug 5) 1944.

because of the constant threat of malignant growth. In spite of careful attempts to correlate the clinical, roentgenologic and pathologic data, there are still possibilities of error in the diagnosis of giant cell tumor, as pointed out by Codman¹⁷. In the first place, the roentgenograms may be characteristic but the histologic picture in favor of some other diagnosis. On the other hand, from both the roentgenograms and the slides the tumor may be interpreted as giant cell tumor, and yet the case may run a rapidly fatal course, indicating that an error was made. Finally, the roentgenograms, sections and clinical course may apparently assure the diagnosis, and yet a sarcoma may eventually appear at the site of the lesion.

Whenever possible, the treatment for pulsating benign giant cell tumor of bone should be wide surgical resection of the involved area. Scott⁶ has reported a case in which the swelling and pulsation subsided after roentgen therapy and in which the patient was well ten months later. A much longer period of follow-up is needed, however, to demonstrate the complete efficacy of this form of therapy. Ewing³ stated that "they do not do particularly well with irradiation and generally terminate in amputation". Although the reported cases are too few to justify definite conclusions, it appears safest at present to reserve roentgen therapy as an adjunct to surgical treatment, particularly for areas of the body in which resection is infeasible and curettage must be employed.

The prognosis as to life itself is good, but in 3 out of the 7 cases a limb was eventually sacrificed. The prognosis locally can be improved by earlier diagnosis and prompt surgical treatment, thus entailing less resection of bone, with resultant decrease in deformity and loss of function.

SUMMARY AND CONCLUSIONS

1 A case of pulsating benign giant cell tumor of bone is presented in detail, and 6 additional cases from the literature since 1900 are reviewed. It is improbable that the lesion is so rare as these few reports would indicate.

2 The histologic picture is indistinguishable from the ordinary variety of giant cell tumor. The pulsation probably depends on free communication of the capillary network of the tumor with its arteriolar and arterial supply, looseness of the supportive stroma and erosion of the bony cortex.

3 This tumor must be differentiated from other pulsating tumors of bone, namely telangiectatic osteogenic sarcoma, metastatic carcinoma

17 Codman, E. A. Treatment of Giant Cell Tumors About Knee, Surg., Gynec. & Obst. **64** 485, 1937.

from the thyroid or kidney and benign and malignant hemangiomatous tumors. Careful correlation of clinical, roentgenologic and pathologic data is required.

4 Treatment should consist in wide surgical resection of involved bone whenever possible. If this procedure is impractical, curettage supplemented by irradiation therapy may be employed.

5 The prognosis as to life is good, although amputation may eventually be required. Earlier diagnosis and prompt surgical treatment will lessen the degree of postoperative deformity and loss of function.

INJECTION INTO PERICARDIAL SAC AND LIGATION OF CORONARY ARTERY OF THE RAT

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DURHAM, N. C.

ACTIVE interest in surgical methods by which deficient circulation in the coronary artery might be supported through collateral vessels was initiated by Beck. This author, as a result of his experiences with the injection of diluted solution of sodium hypochlorite into the pericardial cavity of dogs¹ and of the observations of Hudson, Moritz and Wearn² and of Moritz, Hudson and Orgain³ related to autopsy study of extracardiac circulation in human hearts, began the series of experiments leading to the operations on patients summarized by Beck¹ and by Feil⁴. In current surgical clinical efforts toward the development of extracardiac circulation, openings in the pericardium have been employed through which pectoral muscle or mediastinal fat, (Beck¹) or omentum (O'Shaughnessy⁵) was brought to the heart.

Many investigators have employed irritants to obliterate the pericardial sac by adhesions or to cause grafts to adhere. Beck¹ employed abrasion and powdered asbestos, and O'Shaughnessy⁵ used aleuronat with these grafts in patients. Adhesions of the pericardial sacs of patients have been sought by open injections of aleuronat, limonite (impure native tellurium) and sodium morrhuate by Heinbecker and Barton,⁷ and purified talc by Thompson and Raisbeck.⁸ Rakov⁹

From the Department of Surgery, Duke University School of Medicine

1 Beck, C. S. The Effect of Surgical Solution of Chlorinated Soda (Dakin's Solution) in the Pericardial Cavity, *Arch Surg* **18** 1659 (April) 1929

2 Hudson, C. L., Moritz, A. R., and Wearn, J. T. The Extracardiac Anastomoses of the Coronary Arteries, *J. Exper. Med* **56** 919 (Dec.) 1932

3 Moritz, A. R., Hudson, C. L., and Orgain, E. S. Augmentation of Extracardiac Anastomoses of the Coronary Arteries Through Pericardial Adhesions, *J. Exper. Med* **56** 927 (Dec.) 1932

4 Feil, H. Clinical Appraisal of the Beck Operation, *Ann Surg* **118** 807 (Nov.) 1943

5 Beck, C. S. Principles Underlying the Operative Approach to the Treatment of Myocardial Ischemia, *Ann Surg* **118** 788 (Nov.) 1943

6 O'Shaughnessy, L. Surgical Treatment of Cardiac Ischemia, *Lancet* **1** 185 (Jan. 23) 1937

7 Heinbecker, P., and Barton, W. A. An Effective Method for the Development of Collateral Circulation to the Myocardium, *Ann Surg* **114** 186 (Aug.) 1941

(Footnotes continued on next page)

injected sodium morrhuate into the pericardial sacs of 2 patients by needle puncture without open operation

In early experiments, both the formation and the vascularity of adhesions produced by several substances have been studied. Schildt, Stanton and Beck¹⁰ employed croton oil, oil of santal, solution of formaldehyde, acriflavine, sodium ricinoleate, iodochlorol, tragacanth, purified talc, purified siliceous earth, sand, agar cotton, aleuronat, lionite and asbestos experimentally. Powdered asbestos was finally chosen for use clinically. Heinbecker and Barton⁷ used aleuronat, lionite and sodium morrhuate but discarded these substances for a semisolid mixture of gelatin, aleuronat, starch, glycerin, lionite and water. O'Shaughnessy¹¹ has used aleuronat and a mixture of aleuronat, starch and glycerin. Scola and Stoesser¹² advocated the use of lycopodium. Additional experimental studies of other graft materials, such as the lung, have been made by Lezius,¹³ and studies of other injection materials have been reviewed by the aforementioned authors.

The importance of the use of irritants alone or with cardiac grafts has encouraged this study. Experiments on the rat have been devised to further investigate the effectiveness of several of the aforementioned irritants and of new irritants in the production of adhesions. Experiments were also performed to determine by ligation of the coronary artery the possible effectiveness of the adhesions.

METHOD

Three hundred and eight male and female white rats weighing 200 to 300 Gm were employed. The injection material was introduced through a 24 gage needle directly into the pericardial sac, which was exposed by a small thoracotomy wound, with the animal under positive pressure ether anesthetic. Ligation of the coronary artery was performed through a slightly larger thoracotomy wound. The incision in the pericardium for ligation of the artery was made over the medial border of the left auricle. The artery or the artery and the vein or, in some experiments, only the vein was doubly ligated with 000000 silk sutures between

8 Thompson, S. A., and Raisbeck, M. J. Cardio-Pericardiopexy. The Surgical Treatment of Coronary Arterial Disease by the Establishment of Adhesive Pericarditis, *Ann Int Med* **16** 495 (March) 1942.

9 Rakov, H. L. Therapeutic Pericarditis by Intrapericardial Injection in Chronic Coronary Insufficiency, *Am Heart J* **23** 803 (June) 1942.

10, Schildt, P., Stanton, E., and Beck, C. S. Communications Between the Coronary Arteries Produced by the Application of Inflammatory Agents to the Surface of the Heart, *Ann Surg* **118** 34 (July) 1943.

11 O'Shaughnessy, L., Slome, D., and Watson, F. Surgical Revascularisation of the Heart. Experimental Basis, *Lancet* **1** 617 (March 18) 1939.

12 Scola, J. V., and Stoesser, F. G. The Use of Lycopodium as an Agent to Create a Collateral Circulation to the Myocardium from the Pericardium, *Surg, Gynec & Obst* **79** 497 (Nov) 1944.

13 Lezius, A. Die künstliche Blutversorgung des Herzmuskels, *Arch f klin. Chir* **189** 342, 1937.

the aorta and the division of the coronary artery into the descending and circumflex branches. Observations were made at intervals during surgical exploration or during autopsy.

INJECTION INTO THE PERICARDIAL SAC

Isotonic solution of sodium chloride, 0.2 cc., was injected into the pericardial sacs of each of 20 rats to control the effect of exposure and injection. The hearts of the rats were examined in pairs by surgical exposure or by autopsy at daily intervals up to ten days. The pericardia and the hearts appeared normal. Adhesions or exudates were not observed.

Twenty-five irritating materials and certain combinations were then injected into additional animals to determine their adhesion-pro-

TABLE 1—*Effects of Injection of Several Materials for Production of Pericardial Adhesions Between Heart and Pericardium*

Substance	Rats No	Adhesions		Without Adhe- sions, No	Foreign Body Reaction		Pleural Effusion Degree
		No	Degree		No	Degree	
Acids	24	14	+	10	0		++++
Oils	11	2	+	9	7	+++	+
Cod liver oil and trichloroacetic acid, 2.5%	2	2	++	0	2	++++	++
Proteins	22	0		22	16	++	0
Lycopodium combinations	12	9	+++	3	11	+++	+
Alcohol 7%	2	0		2	0		0
Powder of purified siliceous earth in isotonic solution of sodium chloride	2	0		2	2	+++	0
Urea, 20%	2	0		2	0		0
Sodium salicylate, 20% aqueous	2	0		2	0		0

ducing properties. The materials employed are loosely grouped for presentation into acids, oils, protein, lycopodium, miscellaneous materials and detergents.

Acids—The effects of injecting the several acids into the pericardial sacs of 26 rats are presented in table 1. Acetic acid was employed as a 1.5 per cent and as a 3 per cent solution in sterile water. The 1.5 per cent solution injected into 2 rats produced no adhesions during eighteen days. One of 2 rats into which the 3 per cent solution was injected died after two days of fibrinous adhesions. Hydrochloric acid, tenth-normal, produced no adhesions after fourteen days in 2 rats. Ascorbic acid, 0.5 per cent, produced no adhesions after twenty-five and ninety days in 2 rats. Trichloroacetic acid, 1 per cent, produced no adhesions after twelve days in 2 rats. Trichloroacetic acid, 2 per cent produced fine loose adhesions after sixteen days in 2 rats. Trichloroacetic acid, 2.5 per cent, was injected into 12 rats. Respiratory difficulty developed in 7. When examined at autopsy or killed within

two days of the injections, they had extensive pleural effusion. The pericardial spaces contained fibrinous adhesions. There was dilatation and injection of vessels in the hearts and pericardia. There was also some free fluid. Two rats killed at five days and 1 at ten had fine friable adhesions. Two rats killed at eleven days had no adhesions. Three per cent trichloroacetic acid produced prompt death in 2 rats. Acids in general were poorly effective in the production of adhesions and tended to produce excessive effusion into the adjacent pleural cavity, with respiratory difficulty.

Oils—The effects of injecting the several oils used into the pericardial sacs of 11 rats are presented in table 1. Iodochlorol (Searle) injected into 2 rats produced foreign body reaction. This consisted in the development of granulation tissue over the heart or the surface of the pericardia. The oil was walled off or pocketed. There were no adhesions after twenty-five days. Roentgen ray examination demonstrated that the oil spread through the pericardial space. Peanut (arachis) oil produced a similar foreign body reaction in 2 rats. One of them had a few scattered adhesions. Cottonseed oil injected into 2 rats killed at ten and twenty-five days seemed to have disappeared without producing adhesions or significant foreign body reaction. Cod liver oil injected into 3 rats killed after ten days produced foreign body reaction without adhesions. Cod liver oil and a 2.5 per cent solution of trichloroacetic acid were injected into 2 rats. They produced firm bands of adhesions enclosing pockets of foreign body granulation tissue and cod liver oil after twelve days. Plantago oil (Searle) produced death in 1 animal after two days of pleural effusion. In another animal killed after eleven days, it produced an extensive exudative reaction in the left side of the chest and, in addition, many constricting bandlike adhesions. Oils in general seem to produce foreign body reactions without effectively producing adhesions.

Proteins—Proteins were injected into the pericardial spaces of 22 rats to determine their effectiveness in the production of adhesions (table 1). Clotted human fibrinogen, fresh human plasma and fresh egg albumin were each injected into 2 rats. Adhesions did not develop during ten days of observation. The pericardial sacs appeared normal. Chromicized surgical gut was powdered, suspended in isotonic solution of sodium chloride and injected into 16 rats. It produced a granulomatous foreign body reaction but did not produce adhesions after ten to fourteen days. The proteins used did not produce adhesions.

Lycopodium—The effect of injection of lycopodium into the pericardial sac was tested by insufflation of the dry powder through a needle and by introduction of it as a suspension in the oils previously described in 12 rats (table 1). Insufflation was employed in 2 rats. In

1 adhesions developed over a portion of the heart by twelve days. The other rat, killed after the same time, had none. In 2 rats into which lycopodium powder in cottonseed oil was injected, adhesions and foreign body reaction developed in ten days (fig 1). The suspension in peanut (arachis) oil developed foreign body reaction without adhesions in 2 rats after ten days. The suspension in cod liver oil in 2 rats produced extensive foreign body reaction with a few adhesions ten days after injection. Lycopodium suspended in iodochlorol (Searle) produced a few adhesions and considerable foreign body reaction after ten days in 2 rats. Lycopodium powder and sodium morrhuate, 5 per cent (Searle), in 2 rats obliterated the pericardial spaces. The hearts and the pericardia were involved in foreign body reaction after ten days. The better adhesions of this group were formed by

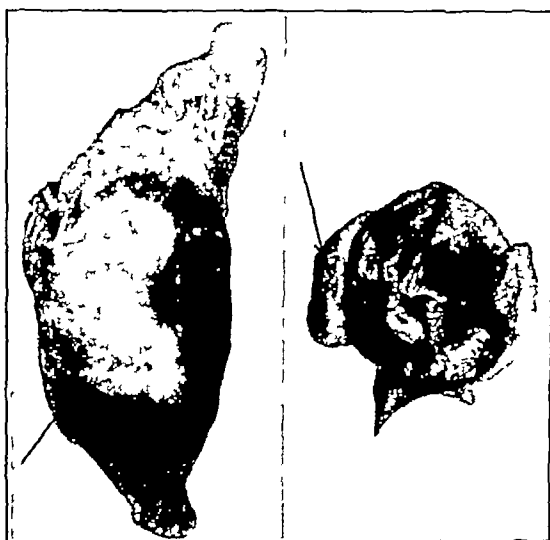


Fig 1—Profile and cross section views of the heart of a rat ten days after injection of lycopodium suspended in 0.2 cc of cottonseed oil into the pericardial sac. The granulomatous foreign body reaction typical of that observed after other oils is indicated by the arrows.

lycopodium powder suspended in cottonseed oil, iodochlorol or 5 per cent sodium morrhuate (Searle). The foreign body reaction around the lycopodium particles was occasionally extensive and caused cardiac constriction.

Miscellaneous Substances—Alcohol, purified siliceous earth and isotonic solution of sodium chloride, urea and sodium salicylate were each injected into the pericardial sacs of 2 rats (table 1). Ethyl alcohol, 7 per cent, did not produce a detectable reaction within fourteen days of the injection. Purified siliceous earth suspended in isotonic solution of sodium chloride produced discrete areas of foreign

body reaction and no adhesions during nine days. An aqueous urea solution (20 per cent) did not produce adhesions during eighteen and forty days. An aqueous sodium salicylate solution (20 per cent) produced no detectable reaction during nineteen days. Croton oil, full strength, quinine hydrochloride and ethyl carbamate (Lilly), full, half and quarter strengths, sodium salicylate, half strength, and Aerosol, OT quarter strength, each injected into the pericardial sacs of 2 rats produced cardiac contracture and instantaneous death.

Detergents—Five salts of fatty acids and two combinations with other material were injected into the pericardial sacs of 128 rats (table 2). A 5 per cent aqueous solution of sodium stearate produced no adhesions in 2 rats during a ten day period. Aerosol, a 5 per cent aqueous solution, was injected into 12 rats. Four died within three

TABLE 2—*Effects of Injection of Several Detergents for the Production of Adhesions Between Heart and Pericardium*

Substance	Rats, No.	Adhesions		Without Adhe- sions No.	Foreign Body Reaction		Pleural Effusion, Degree
		No.	Degree		No.	Degree	
Sodium stearate 5%	2	0		2	0	0	0
Aerosol O T, 5%	12	5	+++	7	0	0	++++
Castile soap	17	0	+++	8	0	0	0
Castile soap, 20%, and tri- chloroacetic acid 2.5%	2	1	++++	1	0	0	+
Sylnasol, 20%.	5	5	++++	0	0	0	+++
Sylnasol, 5% (Searle)	2	1	+++	1	0	0	++
Sodium morrhuate, 20%	26	20	++ to ++++	6	0	0	++
Sodium morrhuate, 5%	53	53	++	33	0	0	++
Sodium morrhuate, 5%, and iodochlorol	2	1	++++	1	0	0	++

hours and 1 after two days from pleural effusion and respiratory difficulty. Seven were killed at ten days. Four had firm adhesions and 1 partial adhesions. Two had no adhesions. Castile soap, a 5 per cent aqueous solution, was injected into the pericardial sacs of 17 rats killed at ten days. Three had complete firm adhesions and 6 partial adhesions. Eight had no adhesions. Pleural effusion was not observed. A 20 per cent solution of the salts of certain fatty acids of oil from a seed of the psyllium group in 5 rats produced complete but loose adhesions of the hearts and the pericardia after ten days and in 3 rats complete firm adherence without constriction after nine months. Sylnasol in 2 rats produced similar but less extensive changes. Twenty per cent sodium morrhuate (Searle) was injected into 26 rats. In 7 complete adherence developed at the time of autopsy ten or more days after injection. In 13 fibrinous adhesions developed one to five days after injection. Six rats examined at autopsy ten minutes, twenty-four hours, four days

and nine months after injection had no adhesions. In 86 rats, 2 cc of 5 per cent sodium morrhuate containing 2 per cent benzoic acid (Searle) was injected. In 21 complete adherence between the hearts and the pericardia developed between ten and two hundred and twenty-four days. The adhesions were seen at autopsy or subsequent operation (fig 2). Fifteen examined at autopsy or exposed at operation between four and ten days after injection had firm adhesions. Eighteen rats killed twenty-four hours to nine days after injection had exudate with fibrinous adhesions over the entire surface of the heart. Seven examined at autopsy twenty-seven, thirty-six, fifty-three, fifty-three, fifty-eight, seventy-six and ninety-one days after injection had only partial adherence between the hearts and the pericardia. In 33 of the 86 rats given injections of 5 per cent sodium morrhuate, no adhesions developed.

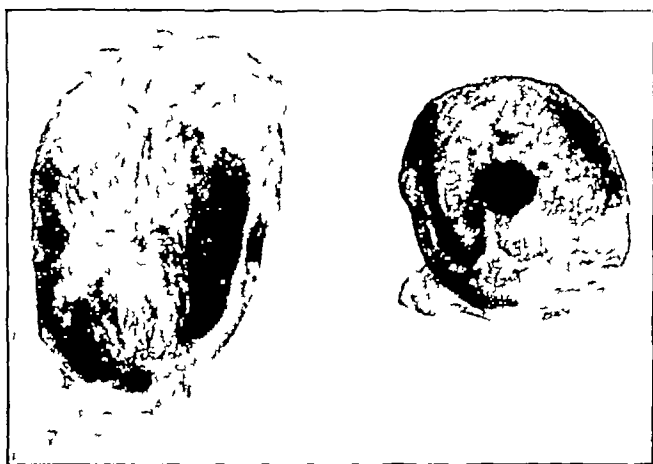


Fig 2—Profile and cross section views of the heart and pericardium two hundred and twenty-four days after injection of 0.2 cc of 5 per cent sodium morrhuate. The pericardium is completely adherent to the heart. Adhesions are fine and firm. Foreign body reaction is not present.

Twenty-three of them were examined less than nine days after the injection and 10 examined later than ten days. In all the rats into which 5 per cent sodium morrhuate had been injected some respiratory difficulty developed after operation but less than in those in which 20 per cent sodium morrhuate had been employed. In 1 of 2 rats into which a mixture of equal quantities of sodium morrhuate, 5 per cent, and iodochlorol was injected firm adhesions developed over the entire heart after ten days. The other, examined at the same time, had no adhesions. An aqueous solution of equal parts of castile soap, 20 per cent and trichloroacetic acid, 2.5 per cent, was injected into 2 rats. In 1, complete firm adhesions developed within ten days between the heart, the pericardium and the thoracic wall. In the other, adhesions did not

develop during ten days. Many detergents effectively produced adhesions. Castile soap was interesting, since it produced adhesions without producing effusion into the adjacent pleural cavity.

LIGATION OF THE CORONARY ARTERIES IN RATS USED AS CONTROLS

Ligation of the left or the right coronary artery or the coronary vein was attempted in 30 normal rats. Twelve more, into which isotonic solution of sodium chloride had been previously injected and without pericardial adhesions at the time of ligation, were also used. Ligation of the left coronary artery, often including the vein, was attempted and examined during autopsy in 34 of these 42 animals. Complete coronary occlusion was effected in 13 rats and probable in 1. The rats listed here and in the following paragraphs as having probable ligation of the

TABLE 3—*Definite or Probable High Ligation of the Left Coronary Artery*

	Animals with Coronary Occlusion	Death During First 24 Hours *	Death after 24 Hours	Killed with Damage to Heart	Killed Without Significant Damage to Heart
Ligation of coronary artery of normal rats	14	3	2	7	1
Ligation within 10 days of injection (heart adherent)	5	3	1	0	1
Ligation within 10 days of injection (no adhesions)	6	2	3	0	0
Ligation 14 to 50 days after injection (heart adherent)	16	3	0	8	3
Ligation 14 to 50 days after injection (no adhesions)	7	1	1	3	2

* Four rats dying during operation from anesthetic or from hemorrhage are excluded from this table.

coronary artery are those that had sufficient density of adhesions at the time of autopsy to obscure accurate visualization of the artery. The ligature was correctly placed. A summary of the effect of complete or probable occlusion is given in table 3. Complete occlusion was associated with death within ten minutes in 3 of the 13 normal rats. Two were killed at twenty-four hours and had extensive necrosis of the left ventricle. One died five days after ligation with a thin and dark left ventricle. One died fourteen days after ligation from pulmonary congestion and pleural effusion. The entire left ventricle was scarred. Five were killed at fourteen, twenty-one, twenty-one, twenty-three and forty-one days and had large, dilated, thin, scarred left ventricles (fig 3) or extensive fibrosis, thinning and scarring (fig 4). One with a probable occlusion of the left ventricle was killed after fifteen days, and adhesions had developed. The cardiac wall showed little scarring. One animal with complete occlusion died of hemorrhage at operation. Autopsy

revealed faulty or low ligature without complete occlusion in 20 of the 34 rats. These animals were killed after a period of twenty-four hours to seven months. Localized adhesions had developed near the ligature in 9. The hearts of 4 rats showed small areas of infarctions.

Ligation of the right coronary artery was attempted in 3 of the 40 rats. One died at operation, and 1 had a faulty position of the suture. The third, killed twenty days after ligation, showed definite occlusion of the right coronary artery, with pronounced fibrosis and scarring of the entire right ventricular wall.

The left coronary vein alone was ligated in 5 of the 40 rats. Examination after ten days revealed no significant pathologic change.



Fig. 3—The thin, scarred, dilated left ventricle of a rat killed twenty-one days after ligation of the left coronary artery.

INJECTION WITH SODIUM MORRHUATE AND LIGATION OF THE CORONARY ARTERY

Ligation of the left coronary artery was attempted and examined during autopsy in 46 rats previously treated by injection of sodium morrhuate. Ligation was performed within ten days of the injection (average five days) in 18 rats and between fourteen and fifty days (average forty-five) in 28. In 7 of the 18 rats that had ligation within ten days of the injection adhesions had developed. Complete coronary occlusion was effected in 5 (table 3). It was associated with death

within ten minutes in 3. Complete coronary occlusion was associated with death in 1 in twenty-four hours and in another, that had pleural effusion, in fourteen days. The hearts in neither animal showed infarction. The coronary occlusion was not complete in 1 killed twenty-eight days later. One rat died of hemorrhage during operation.

Eleven of the 18 rats had no adhesions by the average time of five days that preceded ligation of the coronary artery. Complete coronary occlusion was effected in 5 and probable in 1 (table 3). Complete coronary occlusion was associated with death within ten minutes in 2

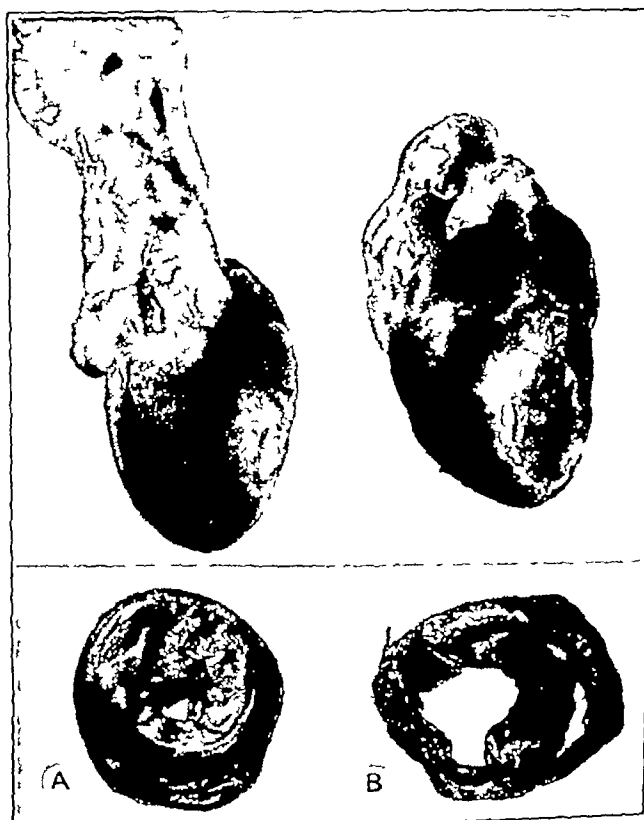


Fig 4—Profile and cross section views comparing the heart of a normal rat, *A*, with a fibrosed, thinned, scarred heart twenty-three days after ligation of the left coronary artery, *B*.

Complete occlusion produced death from infarction of the cardiac wall and pleural effusion in 1 rat at three days and in 1 at eleven. Another died at nine days of pleural effusion but without infarction. One, killed thirty days after operation, had probable occlusion, and firm adhesions had developed without infarction. Of the 5 remaining rats, 2 had the ligatures below the bifurcation of the artery. This was associated with death from pleural effusion in 1 within twenty-four hours, and autopsy

at thirty days in 1 revealed that adhesions had developed since ligation but that there was no cardiac infarction

The artery was missed in the remaining 3. One died at six days, of undetermined cause, and 2 were killed at thirty-two days and had firm adhesions

In 19 of the 28 rats that had ligation fourteen to fifty days after injection, adhesions had developed by the average time of forty-five days, at which time ligation of the coronary artery was attempted. Complete coronary occlusion was demonstrated in 13 rats and probable in 3

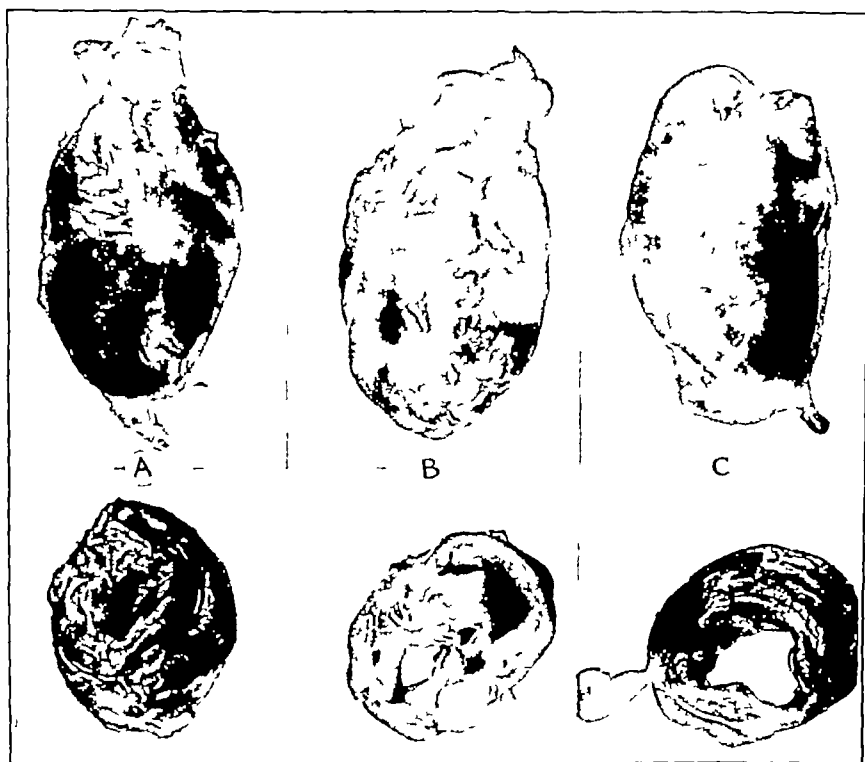


Fig 5—Profile and cross section views of three hearts with adhesions produced by injection of sodium morrhuate into the pericardial sacs forty-nine, twenty-seven and fifty-four days before ligation of the left coronary artery. The first rat (*A*) was killed for examination thirteen days after probable complete occlusion, the second rat (*B*) twenty-eight days after definite complete occlusion and the third rat (*C*) nineteen days after definite complete occlusion. Moderate thinning, fibrosis and dilatation have occurred in *B* and in *C*.

(table 3). Two rats died at operation of hemorrhage. Occlusion was associated with death within ninety minutes in 3 rats. Eight were killed at thirteen, fourteen, sixteen, nineteen, thirty-four, thirty-six, thirty-six and fifty-four days respectively and had thinning and scarring of the wall of the ventricle (fig 5 *B* and *C*). Three others had probable occlusion and when killed at thirteen, fourteen and thirty-six days had dense

adhesions without myocardial damage (fig 5 A) Ligation was low in 1 killed at fifty-five days Adhesions were present without cardiac scar The artery was missed in the remaining 2 and at autopsy at fourteen days adhesions were present without damage to the cardiac wall

In 9 of the 28 rats given injections an average time of forty-five days no adhesions had developed at the time of attempted ligation of the coronary artery, and complete occlusion of the coronary artery was effected in 5 and probable in 2 (table 3) Complete occlusion was associated with death at operation in 1 It was associated with death at eight days in another from an undetermined cause Adhesions had not developed Three animals with complete occlusion were killed at thirteen, twenty-eight and one hundred and fifty-four days respectively and had large scars in the wall of the left ventricle There were no adhesions Probable coronary occlusion in 2 rats killed at thirteen and at thirty-five days was associated with no damage to the cardiac wall and with the development of firm adhesions The coronary artery was missed in the remaining 2, killed at eleven days, without damage to the heart and with adhesions in 1

Injection of 2 cc of 5 per cent sodium morrhuate was also performed in 4 rats that had survived occlusion of the coronary artery between three and nine days respectively One died the day after injection, with necrosis of the left ventricle and fibrinous adhesions Two were killed at fifty-two and fifty-four days and showed adhesions and scarring of the ventricle

SUMMARY

The use of irritating agents in the pericardial sac or between the heart and grafts of muscle, fat or omentum to secure adhesions or extracardiac collateral circulation in patients with coronary heart disease has stimulated this study of irritants and of ligation of the coronary artery in the rat Isotonic solution of sodium chloride injected into the pericardial sacs of 20 rats produced no adhesions Twenty-five irritating materials and certain combinations were introduced by needle puncture into the exposed pericardial sacs of 246 rats Acetic acid hydrochloric acid ascorbic acid and trichloroacetic acid were used in 26 rats and found poorly effective in the production of adhesions They produced effusion into the adjacent pleural cavities Iodochlorol, peanut (arachis) oil, cottonseed oil, cod liver oil and plantago oil were used in 11 rats They produced extensive granulomatous foreign body reaction and few adhesions Clotted human fibrinogen, human plasma, egg albumin and chromicized surgical gut were used in 22 rats They did not produce adhesions Lycopodium suspended in several oils was used and produced extensive foreign body reactions in 10 rats Alcohol, purified siliceous earth and isotonic solution of sodium chloride, urea

and Aerosol were each used in 2 rats often in several strengths, with the varying results described and without good adhesions. Sodium stearate produced no adhesions in 2 rats. Aerosol produced adhesions in 5 of 12 rats. Pleural effusion and respiratory difficulty occurred. Castile soap produced adhesions in 9 of 17 rats and did not produce foreign body reaction or pleural effusion. Sylnasol produced firm adhesions in 10 rats. Twenty per cent sodium morrhuate was used in 26 rats and produced fibrinous or fibrous adhesions in 20. Two rats at ten days and seven months had no adhesions. Four examined before ten days also had no adhesions. Five per cent sodium morrhuate was employed in 86 rats. It produced adhesions in all but 23 examined at less than nine days and 10 examined at more than ten days. Effusion into the adjacent pleural cavity and respiratory difficulty were often encountered.

Ligation of coronary vessels was employed in 42 normal rats. Ligation of the left coronary vein alone in 5 produced no significant pathologic change. Ligation of the right coronary artery was performed in 3, with fibrosis and scarring of the right ventricular wall in 1. Ligation of the left coronary artery was attempted in 34 and successful in 14. Scarring, fibrosis and dilatation of the left ventricle developed in 7.

Ligation of the left coronary artery was attempted in 46 rats after injections of the pericardial sacs with sodium morrhuate. It was successful in 34. Twenty-one had adhesions at the time of the ligation, and 13 did not have adhesions. The effect of the ligation in each group is summarized in table 3. Injections of sodium morrhuate in 4 rats that had survived occlusion of the left coronary artery three to nine days did not prevent death in 2 or damage to the ventricle in 2.

CONCLUSIONS

Many substances produce adhesions when injected into the pericardial sac of the rat. They also produce reactions or complications. Acids produce effusion. Oils and lycopodium in oil produce granulation tissue and foreign body reaction. Detergents produce firm adhesions. Sodium morrhuate produces adhesions and moderate effusion. Castile soap produced adhesions without producing foreign body reaction or effusion into the adjacent pleural cavity.

Ligation of the coronary artery more than ten days after the injection of sodium morrhuate and the development of adhesions of the pericardial sac is associated with as high an immediate mortality and as frequent an occurrence of survival with damage to the heart as observed in the rats used as controls. The degree of damage is slightly less. Ligation within ten days before or after injection is poorly tolerated.

Keith S. Grimson offered encouragement and advice during the experiments and the preparation of this report.

PILONIDAL SINUS

A Review of 130 Consecutive Cases in Which Patients Were Treated by Closure,
A New Closed Operative Method and Management

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AND

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THIS article is a summary of the methods of treatment and the results obtained in the treatment of pilonidal sinus in a ward devoted mainly to proctologic cases at the United States Naval Hospital Chelsea, Mass

In a relatively short period a large number of patients were seen and operated on. In a relatively short period these patients were dismissed free of symptoms and, providing recurrence is not experienced at a later date, which is unlikely in the vast majority, cured. We believe that we are now justified in stating that a new closed operative method can be described, applicable in virtually all cases of pilonidal sinus. We realize that this is a rather sweeping claim to make, but only the extremely rare case will not permit this, such as that in which bone involvement or spinal canal or dural involvement coexist. For in this series not only was the usual simple sacrococcygeal type seen, but many cases also in which involvement was so extensive that any type of previously described closed method could not be used successfully. All cases were consecutive, and all sinuses were resected and closed. The diagnosis was confirmed pathologically in all instances. This paper reviews and evaluates the new method, comparing the usual type of simple closure with that of the new method. The actual operative steps and its description are left to an accompanying article.

The average age of the patients was 23.4 years. Though some patients were obese and some hairy, suggesting an endocrine disturbance, it could not be said to be so in the majority of instances. We suggest that the large number of patients in this age group is caused by sudden stress and strain in a class of persons not properly adapted or accustomed to a rigorous physical program. Inflammation of a pilonidal

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tract, therefore, is more apt to occur from trauma in military life than in civilian life

Many articles have been written on the surgical treatment of pilonidal cyst, with considerable confusion resulting because of methods described as applicable to certain types and not applicable to others and in other instances because of methods not in keeping with advanced therapy

We are in agreement with Magrath,¹ who stated that, through lack of clarity and misunderstanding of the type of pilonidal cyst operated on, many methods described in the past have led to discouraging results. We also agree with him that the name pilonidal cyst is a misnomer and that a pilonidal cyst is in reality a "raphe (epithelial) inclusion"

This study is a surgical review of 130 cases seen consecutively during a period shortly over six months. All the one hundred and thirty cysts were sacrococcygeal in location, were at least recently inflammatory, were symptomatic and in all instances were operated on by a closed procedure. That this was possible in all cases was due to careful preoperative and postoperative care, the use of sulfonamide therapy and penicillin and last, but not least, the application of the new operative procedure. Since the results have lowered the stay of hospitalization even over that of our predecessor, Dr H E Kennard,² who reported excellent results obtained in a series of 50 cases of operation by simple closure, we believe that it is a method worthy of careful consideration. There is no method of treatment, however, but can be improved, and even during the short course of this series changes and improvements were made. Dr Kennard, in his preceding series, established certain steps in the regimen of preoperative and postoperative treatment, as well as in his surgical technic, which in many details deserved duplication.

PREOPERATIVE CARE OF THE PATIENT

Although eleven of the one hundred and thirty cysts were quiescent at the time of operation, all patients not demonstrating a definite sinus, with its dimple and signs of resolving inflammation or active inflammation, coupled with a history of definite troublesome symptoms were refused operation. This meant that many patients required incision and drainage of the abscess, hot wet boric packs and sitz baths preoperatively. One hundred and nineteen cysts were termed inflammatory either by reason of the pathologic report or by the definite demonstration of purulent discharge. One quiescent lesion was a cystic type only chronically inflamed. The patients with cysts incised and drained were

1 Magrath, J L. Pilonidal Sinus or Cyst. A Misnomer, *Am J Surg* **64** 101-103 (April) 1944

2 Kennard, H S. A Method to Shorten Hospitalization of Patients with Pilonidal Cysts, *Mil Surgeon* **97** 132-135 (Aug) 1945

hastened to operation much sooner than was desired, owing to an exceptionally crowded hospital and the need for a rapid turnover. Such patients averaged only two to ten days of preoperative care as compared with the twenty-seven days averaged by Kennard. Many patients were operated on with cysts in fairly active stages of inflammation. This led to an occasional soiled operative field, and, though in many cases no untoward result occurred, the results would have been better if more time and a totally quiescent lesion had been assured preoperatively.

The immediate preoperative steps were directed toward the obtaining of a clean field for operation and in cleansing enemas to prevent bowel movement postoperatively. The day before operation the patient was showered and bathed, the hair shampooed and the nails scrubbed. The pubic, perineal, sacral and anal hair was shaved over a wide expanse. Four quart enemas of hot tap water and liquid petrolatum were given, three the afternoon and evening preceding the operation and one the morning of the operation. Food and liquids were permitted until midnight preceding the day of operation. Pentobarbital sodium was given an hour before operation. Penicillin was started preoperatively one day before operation, 15,000 units every three hours.

OPERATION

Since the operation is one that requires detailed description and explanation, it accompanies this paper as a separate article. Suffice it to say that we include a block excision as the method best assuring against recurrence. If all the offending tissue is removed, postoperative sinuses and pockets are pseudorecurrences. This is in accordance with many authors, notably Tendler,³ Rogers and Hall,⁴ Weeks and Young,⁵ and Barnett.⁶ Kleckner⁷ presented the results of the members of the American Proctologic Society and showed in a review of over 4,000 cases that open resection was least apt to result in recurrence. Lahey⁸ stated, "Wide dissections and complete removal of pilonidal tracts are necessary in order to prevent recurrence of pilonidal sinus."

3 Tendler, M. J. Pilonidal Sinus. A Review of Its Literature and a Report of 87 Cases, *South M. J.* **34** 1156-1168 (Sept.) 1941.

4 Rogers, H., and Hall, M. G. Pilonidal Sinus. Surgical Treatment and Pathologic Structure, *Arch. Surg.* **31** 742-766 (Nov.) 1935.

5 Weeks, R. B., and Young, G. G. Sacrococcygeal Cyst. Report of Two Hundred Cases in an Army Hospital, *Am. J. Surg.* **60** 260-263 (May) 1943.

6 Barnett, L. A. Pilonidal Cyst. The Post-Operative Problem, *Am. J. Surg.* **64** 338-345 (June) 1944.

7 Kleckner, M. S. Pilonidal Sinus. Its Surgical Management, *Tr. Am. Proct. Soc.* **37** 166-172, 1936.

8 Lahey, F. H. A Further Suggestion for the Operative Treatment of Pilonidal Sinuses, *Surg., Gynec. & Obst.* **54** 521-523 (March) 1932.

Therefore, though recurrence may occur at a later date, the importance of the surgical procedure is limited in its relationship to such a misfortune dependent mainly on the skill and experience of the operator in the extirpation of the offending tissue. We are convinced that block excision should be the method of choice best assuring freedom from recurrence, since scar and inflammation many times prevent the visualization of this epidermal tissue much less its successful removal.

As already stated, many papers report the various means of excising pilonidal sinus and advocate many methods for varying types of involved tissue areas. Thus Rogers⁹ reviewing the cases at the Massachusetts General Hospital from 1924 to 1931, in 119 patients reported 36 per cent "recurrence" in primary suture, 50 per cent in partial closure, 18 per cent in open packed incision and 30 per cent in all combined methods. Silverman,¹⁰ in reviewing 85 cases from 1931 to 1934 of the Jewish Hospital in Brooklyn, cited 30 per cent "recurrence" in closed operation, 26 per cent in partially closed operation, 21 per cent in open operation and an average of 25.5 per cent in all types. Kooistra,¹¹ in a review of 89 cases, showed permanent cure in 72 per cent, in which excision and packing, excision and partial closure, excision and closure with later pack, excision and primary closure or excision with primary closure and drain was done. Breidenbach and Wilson¹² cited excision with various types of suture, drain or packing, with 73 per cent cures. Many articles with similar results could be cited. We believe that with the recognition and acceptance of block excision, and thereby the increased likelihood of a complete removal of the pilonidal tissue, combined with a good operative closure and aided by sulfonamide and penicillin therapy much confusion concerning the type of procedure to use will be removed. Since our described method of preoperative and postoperative care combined with a closed operative procedure described in the accompanying article, has given excellent results, we advocate its more general adoption and the sound principles of surgery which it follows. The chief point of merit lies in the fact that it is adapted to extensive pilonidal cysts in which simple primary closure fails. In addition good reason dictated its use in the simpler cases as well as in the extensive high low or laterally extending ramifying lesions. In this series primary closure was used in all cases,

9 Rogers, H. Pilonidal Sinus. *Surg Gynec & Obst* **54** 803-810 (Dec) 1933

10 Silverman, I. Pilonidal Sinus and Its Treatment. *New York State J Med* **39** 1598-1602 (Aug 15) 1939

11 Kooistra, H. P. Pilonidal Sinuses. *Am J Surg* **55** 3-17 (Jan) 1942

12 Breidenbach, L., and Wilson, H. L. Pilonidal Cysts and Sinuses, *Ann Surg* **102** 455-463 (Sept.) 1935

and in the last four months the new operative procedure was used routinely in all cases excepting 4, in which the cysts were closed by simple closure. During the latter period a total of 83 patients were operated on, 79 operations being by the new operative method. In the total series of 130 cases, all operations were by primary closure. 92 were done by the new procedure and 38 by simple closure.

Two cases not reported in this series but seen consecutively with the group of 130 cases were cases of anorectal dermal sinus, or, as might be termed with our misnomer classification, anorectal pilonidal sinus. Both these cases had associated sacrococcygeal pilonidal sinuses as discrete entities. Excision was open. They are being reported on in a separate article.

POSTOPERATIVE CARE OF THE PATIENT

Though initially penicillin was administered for four days postoperatively, before the series was half over it was given routinely, 15,000 units every three hours for eight days postoperatively. Administration of sulfadiazine and sodium bicarbonate, each in 15 grain (97 Gm) doses administered every four hours, carried for eight days postoperatively in the early series, was later extended to the tenth postoperative day. However, the midnight and early morning hour doses of both penicillin and sulfadiazine with the sodium bicarbonate were omitted throughout, it being believed that an uninterrupted sleep permitted a smoother-running busy ward and a happier, rested, and thereby healthier, patient. A strict nonresidue diet, avoiding milk, was used routinely through half the series and then extended to the tenth postoperative day. The exceptions to this were 2 cases of dysentery, 1 a case of proved amebic disease, the condition in both being controlled by antiamebic treatment. Bowel movement was allowed to come of its own accord, without need or resort to enemas, when all medication was stopped on the tenth day and a soft diet was started. As an almost invariable rule, no bowel urge occurred until this period. The patient was not encouraged to go to stool until bowel urge necessitated and was not allowed out of bed until then. A young, vigorous age group permitted this strict regimen. Surprisingly little loss of weight occurred, and this was quickly regained. No ill effects were encountered. Possibly patients in whom the lesion was complicated with cardiorenal disease or other patients should have this interval of time shortened.

RESULTS

The evaluation of the surgical results of this type of treatment and management requires first an acceptance of certain basic facts.

First, it must be realized that with the military, in rather pronounced contradistinction to the usual civilian status, a healed wound

means a wound ready to stand all the vigorous strain and abuse that ordinarily is not required in civilian life. Away from hospital centers, a slight complaint, in the eyes of a pharmacist's mate, may assume enough significance to seem a grave condition. Thus, a small break in the skin, with its moisture and seepage, or a minute postoperative sinus is a "recurrence" in the eyes of both the patient and his young and inexperienced medical counselor. When this occurs, another physician, not thoroughly conversant with the subject, is also apt to probe and incise in the attempt to diagnose or perhaps variously treat a condition best left alone. Consequently, differing from private practice, hospitalization is necessary until no further medical care is necessary and healing is complete to the last portion of epithelium.

An unfortunate, disturbing and in some ways somewhat ludicrous occurrence was periodically reported. Some patients from overseas or in line for overseas duty would maliciously attempt to break open their incisions or produce postoperative sinuses. "Bed bouncers" were reported generally but were specifically named only rarely. Occasional broken wire sutures attested to at least overactivity on the part of patients in bed. For these and other reasons it is our belief that even better results, with fewer complications, will be obtained in civilian practice.

Naturally, an operation that leaves an excellent protective pad of tissue, that no type of open operative operation can profess to do, is necessary for most military personnel. A successful closed operative procedure obtains a good tissue covering in an otherwise poorly protected area over the sacrum. The new operative procedure offers more

Time is an urgent factor in military medicine. The Navy's slogan "As many men, at as many guns, as many days as possible," was ever foremost in our minds. For this reason more than any other, a short period of convalescence was a vital necessity. Overcrowded wards and a hospital operating beyond capacity likewise demanded it. Though patients returned to duty in some cases too soon after operation the majority were returned in about three weeks, the average number of postoperative days of treatment in the group without complications being seventeen and one half. It is our opinion that a good rule to follow in a normally healing closed procedure is to keep such patients in the surgical ward, with no outside liberty for fifteen to sixteen days postoperatively, and to arrange their discharge to permit full duty no sooner than three weeks postoperatively. On reflection this seems logical, since eighteen to twenty-one days is the normal period necessary for fairly complete reparative healing changes to occur in any wound and it is a well known fact that further fibrous healing change occurs even after that period. The acts of sitting and walking subject the healed wound to more strain than wounds from most operations. The anatomic

configuration with the natal crease and gluteal folds, and the spreading strain and tension coincident to the mere act of leg movement and sitting require a solid wound

We do not believe that in civilian practice it is necessary to keep the patient with the uncomplicated wound in the hospital over two weeks postoperatively. Furthermore, small breaks in the skin that required a longer postoperative management in the United States Naval Hospital should be of no concern in civilian practice and in most instances should not require further hospitalization, as was true in this series

With these facts in mind, we reasoned on this basis that the cases without complications in this series of 130 cases should include those requiring no more than thirty days of postoperative care, particularly as this group besides the cases of perfectly healed wounds, included only cases of cutaneous irritation and superficial, small breaks in the skin that healed readily. This group consisted of 108 cases, or 83 per cent of uncomplicated conditions in the series of 130. The patients required an average postoperative care of only seventeen and one-half days

THE GROUP OF CASES WITH COMPLICATIONS

In this group we classed all cases in which, by reason of infection and tissue break, the patients required treatment over thirty days. These numbered 22 cases. In 1 case, a recurrent lesion required reoperation and is not included as a complication. The therapy is listed as a failure. However, operative healing was complete except for a persisting sinus. This constituted 16.9 per cent of the total series.

Simple closures applied to the cases of simpler operation in the early part of the series, until discarded almost entirely in the later half, had a higher incidence of complication, eight of the thirty-eight simple closures, or 21 per cent, being complicated. The new operative closure showed relatively fewer complications, fourteen out of ninety-two such closures, or 15.2 per cent, being complicated. When the fact is considered that this new operation was applied in many cases of severe degree, with extensive involvement, in which the usual simple closure was impossible, the merit of the operation itself is more obvious. When the number of postoperative days of care necessary is compared, the complicated simple closure required 55.1 days of average care as compared with 44.6 days in the complicated new operative procedure. An analysis of the individual complicated cases of simple closure demonstrated the reason as due to results in 3 of the 8 cases. The lesions separated down to the base of the wound, with a subsequent need of ninety-seven, sixty-two and fifty-eight days of postoperative care. All complications with the new operative procedure were breaks of the superficial structure of the wound which, though in some instances

were accompanied with infection and hemorrhage in the deeper portion, healed with greater rapidity. It is evident, therefore, that the advantages of the new operation under identical conditions of management and care were fewer complications and requirement of less time to heal.

CARE IN THE CASE OF COMPLICATION, ITS PREVENTION

As already stated, the greatest difficulty experienced was in the prevention of breaks in the skin. Experience has shown that the silk suture of the skin is preferably left intact until the tenth postoperative day. Great care must also be taken in exposure of the wound. The adhesive tape should be cut at the side of the dressing and turned back rather than peeled off. If stitch abscess or infection is present, lateral tension may further separate. Adjacent sutures may sometimes be left intact for another several days to prevent further separation of the skin. Since this stage of superficial or deeper infection has weakened the tissue to a varying degree, the supporting action of the adhesive dressing is even more necessary. Though early treatment with irrigations, dry heat and open air is many times highly desirable, it should be postponed for a few days, until the wound is more solid. Frequently, daily or twice daily dressings must also be reapplied, the dressing must be mounded so as to secure anterior-posterior downward pressure and great care must be given to the adhesive straps, which are carried anteriorly over the anterior iliac crest and abdominal wall, new adhesive tape being placed over the old, original straps. When conditions permitted, various methods to overcome infection were used, viz., irrigation of cavities with 1:6,600 chloroazodin and cleansing with isotonic solution of sodium chloride with aqueous merthiolate, 70 per cent alcohol and such. Infra-red lamp therapy was used as soon as the wound could be left open. Sitz baths were later used when desirable and when solidity of tissue and the degree of healing permitted.

Hot weather, perspiration and macerated skin were particularly difficult factors in that a phagedenic infection with hemolytic streptococci and *Bacillus pyocyaneus* was apt to occur. Anaerobic infection in such circumstances was more prone to occur, since the compression bandage excluded air. The proximity of the anus was a menace, particularly when the wound by necessity carried into the substance of the anal margin and involved the external subcutaneous sphincter. It was necessary to excise skin margins in such circumstances and to treat them with hydrogen peroxide and zinc peroxide paste. The resultant open area was usually depressed, was slow in forming granulations and was indolent. Six patients with cysts in this stage were treated by an excision of this ulcer and suture, penicillin being used by instillation and hypodermic injection for four to six days. Five cysts healed by primary

intention and one rapidly in spite of only a partially successful skin closure. Removal of heavy scar was responsible for the success of this skin closure. Such secondary closures of the skin should undoubtedly have been resorted to in other cases as part of an early routine in such minor complications.

Small postoperative sinuses were treated in the last few weeks of this series by the injection of a modified Carnoy solution, as described by Cutler and Zollinger,¹³ after all acute inflammation had subsided. It also was a method that should have been used routinely, since it was found highly successful, two or three injections every one to three days alone sufficed to secure solid healing. The solution was prepared according to the following formula:

Absolute alcohol	6 cc.
Chloroform	3 cc
Glacial acetic acid	1 cc
Ferric chloride	1 Gm

THE SEVERELY ABSCESSSED AND INFECTED WOUND

Such a complication as severe abscess and infection in the simple closure resulted in wounds difficult to heal and in 3 cases, as already stated, changed the closed wound into one widely separated, resembling an open block excision type of wound after infection and cutaneous necrosis had subsided.

In cases in which such severe infections occurred in the new type of operation, the deeper structures and muscular layer remained intact and healing was relatively rapid. In consequence, a good covering of tissue was still present over the sacrococcygeal region, a result highly desirable, since the operation aimed for not only rapid healing but a good protective pad of tissue. Frequent dressings, prolonged use of adhesive binding, sitz baths when permissible, infra-red lamp therapy and irrigations with isotonic solution of sodium chloride and 1:6,600 chloroazodin, and, of course, a temporary additional course of penicillin were the chief additional adjuncts of therapy.

COMMENT

Whereas it is apparent that no single operative procedure can in itself alone be responsible for a cure of this condition, it is apparent that the operation in itself is largely responsible for the successful outcome, especially when the success of the outcome is judged in terms of hospitalization and care necessary for cure. When judgment is also directed to the type and quality of the postoperative wound, emphasis is again more properly directed to the importance of the operation in determining the excellence, or otherwise, in the securing of the result. Certainly some operative cures do not result in satisfactorily protected

13 Cutler, E. C., and Zollinger, R. The Use of Sclerosing Solutions in the Treatment of Cysts and Fistulae, *Am J Surg* 19: 411-418 (March) 1933

areas but, as in an open block excision, are subject to criticism in the retracted, denuded and scarred site of healed sacral or sacrococcygeal exposure. Sulfonamide therapy is certainly a requisite in aiding the successful outcome of what could otherwise be an unsuccessful procedure. Likewise, penicillin therapy must be of aid in combating strains of streptococci that might otherwise prove disastrous. One of us had resort to this new operative procedure, with varying fair to excellent results, before penicillin was available. The excellent results in the simple closed procedure by Kennard, as previously mentioned, show that penicillin is not an absolute requisite.

It seems only logical to assume, however, that all points concerned in the careful preoperative and postoperative care and treatment of these patients must be of importance in securing a rapid and successful surgical cure and normal functioning anatomic part.

Emphasis is also given to the important fact that all 130 patients were surgically discharged as healed. Recurrences are, of course, possible if any pilonidal tissue remains. It has been found impossible to follow these cases for future check-up. On the basis that a block excision has had no known recurrences in some 42 cases in the private practice of one of us, it is at least hoped that such is true in this series. The 1 case of a known recurrent lesion typifies, however, the impossibility of being surgically perfect.

That the new operative procedure is one that should be used routinely seems apparent because of the eventual good result in spite of complications and also because of the further reduction in the incidence of complications. The accompanying table clearly demonstrates the point in question.

Results of Operation on Pilonidal Cysts

	Number of Cases and Percentage of Total Series		Number of Cases of Uncomplicated Cysts and per Cent of Group		Average Number of Days of Treatment of Uncomplicated Cysts	Number of Cases of Complicated Cysts and Percentage of Group		Average Number of Days of Treatment of Complicated Cysts
	No	Per Cent	No	Per Cent		No	Per Cent	
New operative procedure	92	70.7	78	84.8	17.4	14	15.2	44.7
Simple closure procedure	38	29.2	30	78.9	17.6	8	21.0	55.1
Total	130*	100	108	83.0	17.5	22	16.9	48.5

* One additional case should be listed as failure due to incomplete excision.

We believe that in civilian practice with more time taken in the preparation of the patients so as to obtain a totally quiescent lesion complications would show an extremely low figure and the rapidity of healing and convalescence would be further improved.

CONCLUSIONS

1 A review is given of 130 consecutive cases of inflamed pilonidal sinus, with a combined type of operative management and a new operative closed procedure

2 Part of this series was a control group in which a simple operative closure was used

3 Penicillin and sulfonamide therapy was used as a successful adjunct

4 The careful preoperative and postoperative care is given, and treatment to avoid as well as to treat complications is described

5 The advantages of the new operative procedure seem demonstrated by the lowered incidence of complications, for the greater part minor

6 Complete healing occurred in all cases

7 Future recurrence depends entirely on pilonidal epithelial remnants being left but is likely to have a low incidence since block excision preceded closure in all cases

8 The operative procedure is given detailed description in the accompanying article

NEW AND SUCCESSFUL CLOSED OPERATIVE PROCEDURE FOR PILONIDAL SINUS

Gluteus Maximus Mobilization A Sliding Muscle Graft Procedure

COMMANDER CHARLES E POPE (MC) USNR

THE operation explained in this paper, a sliding gluteal muscle graft, has gradually evolved to its present completed state, commencing in 1942 to 1943 at the United States Naval Hospital, Mare Island, Calif, where I first devised and used it. Initially used as a closed procedure when the extensive involvement of tissue prevented closure by any other means, the merits of the procedure and its improvements finally permitted its use in all cases.

The purpose of this article is to describe the technical details of the operation and the surgical principles it entails. A combined method of management of pilonidal sinus and a review of ninety-two successful operations demonstrating its applicability accompany as a separate article. It is, therefore, no hurried judgment that asks for counsel and, though improvements may yet occur, I believe that no considerable change is indicated.

Numerous articles describing various operations for pilonidal sinus group them roughly into three groups, that is, open operations, closed operations and partial closures. The last may be said to include the closure type with drainage and also the types which in several ways marsupialize the wound, primarily for the purpose of more rapid healing. It may also be stated that since the advent of sulfonamide therapy and penicillin therapy a large number of papers have advocated a closed procedure, particularly since military surgical procedures drew close attention to the prevalence of pilonidal sinus in the young age group. It is immediately evident that a certain number of methods and procedures accepted in the past can be discarded or at least considerably modified in view of this advance in therapy. It is also evident that a closed procedure is not in itself a new procedure, since in many centers it is used successfully. Certain definite failings however are manifest in the usual closed or partially closed procedure.

In the first place since most excisions expose the sacral fascia a relatively avascular area of tissue is present, showing, therefore, poor

Dr Emile F Holman, Dr Henry W Hudson, Dr H S Kennard and my commanding officers at the United States naval hospitals, Mare Island, Calif and Chelsea, Mass, gave professional courtesies, encouragement and helpful advice.

healing qualities. Coaptation of tissue over this area is usually by a layer of subcutaneous fat and overlying skin, a combination prone to infection, and a dead space poorly filled and prone to the accumulation of serous or sanguineous exudate.

Closed procedures are limited in their applicability, since frequently, and especially with an extensive pilonidal sinus, closure is under undue tension. As a result, such closures effected are liable to failure due to early postoperative splitting, infection, hemorrhage or tissue necrosis. When technically impossible to effect the closure, recourse is had to partial closures or drainage types of procedure or else an open wound is left, necessitating a prolonged period of healing. Such procedures, especially the open type and those marsupializing the wound, leave a healed wound that has much to be desired, since an inadequate covering is left over the denuded sacrococcygeal region. Not only is the last stage of such healing often particularly difficult to attain, but strenuous physical activity must be avoided during the many weeks of healing. Because of the vulnerability of the area, it is prone to injury and not infrequently remains sensitive. In military life it does not seem the best way of dealing with the condition, and, in fact, most authors are now agreed that the open operation in military life should be outlawed. One such lesion seen at the United States Naval Hospital, Mare Island, Calif., remained unhealed seven months after operation and several two to three months or more following the open procedure.

The new operation, involving mobilization of the gluteus maximus muscle, successfully overcomes the numerous disadvantages of other types of pilonidal operations, whether they be closed, open or partially closed. The advantages of a muscle operation occurred to Ottenheimer,¹ but the operation was not attempted. In discussing the difficulty in healing due to faulty obliteration of dead space at operation, he stated, "Delayed dead space formation might be avoided if we could successfully interpose muscle between fat and bone to afford a resilient base for the scar in the fat. It might be possible to turn into the cavity, for example, two butterfly wings of gluteus muscle, one from either side."

Hipsley² unsuccessfully attempted this method suggested by Ottenheimer, reporting 6 cases in which a gluteus maximus flap was drawn subcutaneously into the wound and primary closure attempted. Complications due primarily to bleeding occurred, but, though the wounds became open, healing by reason of the vascularity of the muscle and obliteration of faulty dead space was exceedingly rapid. Hipsley therefore stated the belief that the method was well worth modification, improvement and further trial.

1 Ottenheimer, E. J. Pilonidal Sinus, *Am J Surg* **2** 120-122 (July) 1933

2 Hipsley, R. W. An Operation for Pilonidal Sinuses, *Am J Surg* **63**: 357-361 (March) 1944

Similarly, Miscall and Holder³ also reported an operative procedure, with closure, by the turning of bilateral musculofascial flaps of gluteus muscles onto the sacrococcygeal fascia surface and the suturing of all tissue layers in the midline. Their operation lays fascia against fascia and requires wide block excision to expose the gluteus muscles for subsequent flap dissection. Mobilization of tissues to secure freedom from tension requires further lateral incision, both subcutaneously and intramuscularly, to cover the defect from wide block excision, technically necessary. They report 22 cases in which results were successful, with rapid healing and short hospitalization.

As will be seen, both operations differ materially from the sliding muscle graft, to be described, and are technically more difficult to perform.

Since the usual or modified closed procedure inadequately closes a dead space or is under undue tension and in many instances cannot be successfully performed, a gluteus maximus muscle mobilization was devised, with the following merits: (1) adequate replacement of dead space by a muscle-sliding graft, (2) freedom from tissue tension by muscle mobilization, (3) increased blood supply, increased rapidity of tissue healing and enhanced ability to combat infection by reason of the muscle graft and supple tissues, free from tension, (4) a more adequate protective pad of tissue covering an exposed defect in an otherwise relatively avascular area, where exposed sacrococcygeal bone and fascia require protection, (5) a greatly increased therapeutic effect from sulfonamide and penicillin therapy by the blood stream route, for obvious reasons, (6) a procedure adapted to all cases excepting those in which, rarely, spinal or bone involvement occurs and (7) the permission of a block excision, which has been recognized as least apt to leave offending tissue and to allow subsequent recurrence.

No operation known is free from complications. Operative complications are more frequent in the infected condition and are applicable to infected pilonidal sinus. Consequently, the operation is best performed after infection has subsided, and the longer the period following the initial incision, drainage and inflammatory changes, the less chance for postoperative infection complications and resultant failure. A combined method of treatment should always be conducted and great care directed toward even apparently minor details, which otherwise may cause a rapidly increasing hazard through their neglect or omission. Since detailed facts in the combined method of manage-

3 Miscall, L., and Holder, J. E. Pilonidal Sinus. A Method of Closure by Musculo-Fascial Flaps. *Mil. Surgeon* 93: 457-461 (Dec.) 1943.

ment of cases have already been covered in the accompanying paper, these will not be enlarged on

That the series of one hundred and thirty operations should have shown fewer complications bears mention. So many patients were seen, so overcrowded were the wards and so crowded to capacity was the operating room schedule that the practical solution seemed to be in operation on the inflamed sinus before complete resolution had occurred. That good results were obtained in spite of an occasionally contaminated field of operation speaks well for the procedure even though far from flattering to the operator.

Recurrence may be experienced in some cases, since 1 case of a known recurrent lesion is included in the series and one cannot profess perfection. Since block excision and the open method used in private practice were highly successful in allowing no known recurrence in a series of over 40 cases, this series should have a low incidence, block excision having preceded the surgical operation of closure. It is unfortunate that a follow-up is impossible in this series. It was attempted in the early cases of operation at the United States Naval Hospital, Mare Island, Calif., and was found impossible to obtain.

THE PRINCIPLES OF OPERATION

To accomplish healing by first intention, it is important that the involved tissue is handled with care not only to avoid trauma but likewise to avoid contamination, since many of the cases show buried infection in the depth of scar tissue which probing and incision do not always demonstrate preoperatively. Bleeding must be properly controlled, but a minimum of hemostatic sutures is desirable, since the less foreign substance incorporated in a wound potentially or definitely infected, the better the outcome. Undue tension of the tissue should be averted by avoidance of tight suture, whether retention, skin or mattress suture, and yet a careful approximation of all tissue layers must be obtained. Above all is the need for the obliteration of all dead space. The operation demands these requisites so necessary to all good surgical treatment. Disregard of these necessary surgical principles is apt to result in failure or complications, which is not strange when one remembers that before the use of sulfonamide drugs and penicillin to close such lesions was many times contrary to good surgical judgment. Careful bandaging and care are likewise necessary postoperatively, with bed rest, bowel movements being prevented before healing is complete so as to avoid soiling and contamination and preventing the trauma that might otherwise occur.

The operation was performed in 92 cases. Thirty-eight simple closures were likewise done, which served as a control series. The operation was finally adopted as a routine procedure in all cases.

THE BLOCK INCISION

The block incision, the preliminary and initial step, is highly important in that complete excision of all offending pilonidal tissue is necessary to assure against recurrence. It must be done neatly and with painstaking care, so that exacting coaptation of tissue may later follow.

The patient is preferably placed in reverse Trendelenburg position, with side straps of adhesive tape to withdraw the upper part of the buttocks for better exposure. This method, originated by Bearse, is exceedingly helpful. Care should be taken that the straps are well beyond the field of operation so that later contamination may not occur.

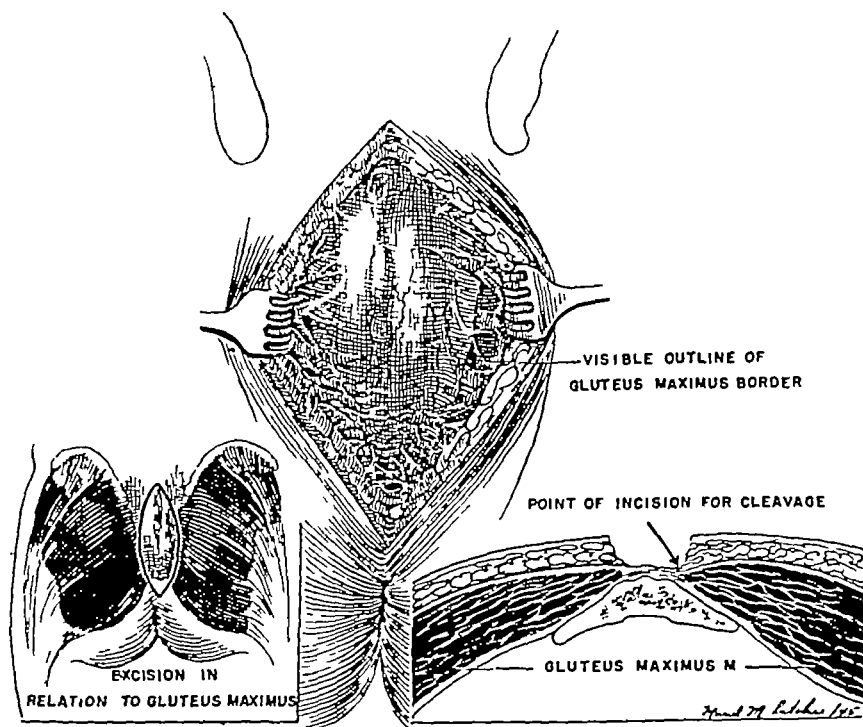


Fig 1—Semischematic illustration demonstrating block excision of pilonidal sinus

In preparation of the field for operation, antiseptic is used on the adhesive tape but contact of the tape with both ether and alcohol is avoided

The previously prepared field of operation is now cleansed with ether, followed by merthiolate. The anus has previously been covered with a wedge of gauze between the buttocks to protect its surface and to wall it off from the field of operation.

The incision is usually elliptic, is made at right angles to the cutaneous surface on its rolling plane and carries well beyond the point of tissue involvement in the sacrococcygeal area. The points of the ellipse

should always be in the median raphe. The location is determined by careful probing of the sinus and by palpation in advance of the incision. Symmetry of its sides is desirable but not entirely necessary or always possible, when lateral extension forbids. Lateral extension requires at times a lateral Y for lateral closure of the ellipse. The zone of incision is aided by a light marking on the skin with the back of the blade or the point of the scalpel. Care must be taken that the sinus does not contaminate the gloves, the scalpel or the instruments.

The skin scalpel is discarded. The upper pole is grasped with an Ochsner or Kocher clamp, and, with a new scalpel, the incision is carried on the top and adjacent sides through fat to sacral fascia. Almost invariably it will be found necessary to carry to this depth. The side incisions should not carry laterally outward but preferably slightly saucerize by medial direction. A sweeping incision by the scalpel strips the raised block of tissue from the sacral fascia and when necessary includes an outer layer surface of its substance. The swinging of the elevated tissue from side to side permits good symmetry of excision, avoids incision of the cyst and tracts and permits a desirable smoothness of procedure. As the lower pole is approached, care must be exerted first to carry the excision close to and carefully over the coccyx, so that, when not necessary to excise, the anococcygeal ligament remains intact. Low extending tracts require care in their excision so as to avoid injury to the posterior part of the rectum, levator musculature and anus. This excision of the lower pole is materially aided by the exertion of more traction once the lateral incision has carried deeply enough beyond the coccyx, for, by so doing, one finds that the fat will peel away without the need of deep incision. This avoids too deep a sulcus wound in closure.

During the block excision, clamping of bleeding vessels impedes the procedure and is to be avoided when possible until the block of tissue has been removed. Frequent sponging is necessary, but, for fear of contamination, each sponge is thrown away as rapidly as used. It is usually possible to determine the deep scarred limits of the tract, visible as a rule on the under surface of the elevated block. Careful scrutiny of both the wound and the specimen removed is necessary, and suspicious areas should be removed. When the tract is cut inadvertently, a reexcision should go beyond the point or area of tissue error, a new scalpel being used and the old discarded. The excised block of tissue may be incised and examined if handled so as not to invite contamination.

A Y extension beyond the sacral fascia anatomically carries over the gluteus or occurs perianally, permitting closure as a simple problem, since there is no dead space as is found in the sacrococcygeal region. Such lateral Y tract wounds have an adequate blood supply and may have muscle at their depths. If pilonidal sinuses were solely confined to

such areas, no surgical problem of moment would exist. The extension usually is the extension of the inflammation rather than that of the pilonidal tissue. Its excision, however, precludes the possibility of leaving pilonidal tissue occasionally present in wide lateral or downward extensions. Excision is necessary also to secure good aseptic closure. Therefore, excision rather than incision should be done.

Since a hot isotonic solution of sodium chloride is used both now and later to control bleeding, it will be found possible to use fewer surgical gut ligatures. These should be a figure of eight suture ligature, mass ligature being carefully avoided, with no 00 plain surgical gut, thought the most desirable, so as to avoid excessive or unnecessary foreign body reaction.

THE GLUTEUS MAXIMUS CLEAVAGE MOBILIZATION

Experience has shown that a single side of gluteus mobilization in practically all cases suffices to mobilize the widest areas of lateral excision.

The gluteus maximus muscle is attached to the lateral surface of the sacrum and coccyx, its posterior surface curving backward in a plane raised beyond the posterior surface of the sacrum. From this area of attachment its fibers fan superiorly slightly upward, in midsacrum laterally and in the sacrococcygeal lower pole in a slightly downward direction. Its strong fascial covering fuses with the sacral and sacrococcygeal fascia. On the side desired, the outer layer of muscle is disengaged from this attachment. The side opposite the area of lateral extension may be most desirable. The adhesive ties now should be disengaged from attachment to the operating table to facilitate the cleavage. A plane of muscle tissue, with its superimposed and attached fascia, subcutaneous fat and skin overlying is obtained by muscle cleavage separation through forcible blunt lateral dissection. In detail, this is done as follows:

The base of the wound is carefully palpated to determine the rolling edge of sacrum and the gluteus attachment. The scalpel, held carefully, cuts muscle and fascia at this edge from top to bottom, following the rounded curve of sacrum and coccyx in the superior-inferior as well as in the anteroposterior plane. An equidistant depth of muscle thickness is obtained approximately half through the muscle. A smooth stroke of the scalpel prevents a ragged edge of muscle or torn fascia, which would be undesirable. The insertion of the operating fingers then permits by forcible lateral and upward and downward extension a blunt cleavage separation that is relatively bloodless. This may be carried as far laterally as is necessary for supple closure of the wound. In general, one and one-half times the size of the base of the wound

is found to be the required distance of lateral cleavage. Usually a further small incision of the lower gluteal fibers at the ligamentous attachment at the lower coccyx level is now necessary so that the full cleavage mobilization may be realized.

Bleeding occurs momentarily and profusely from arteries of the sacral muscle bed, in which a smooth cuff of muscle tissue is allowed

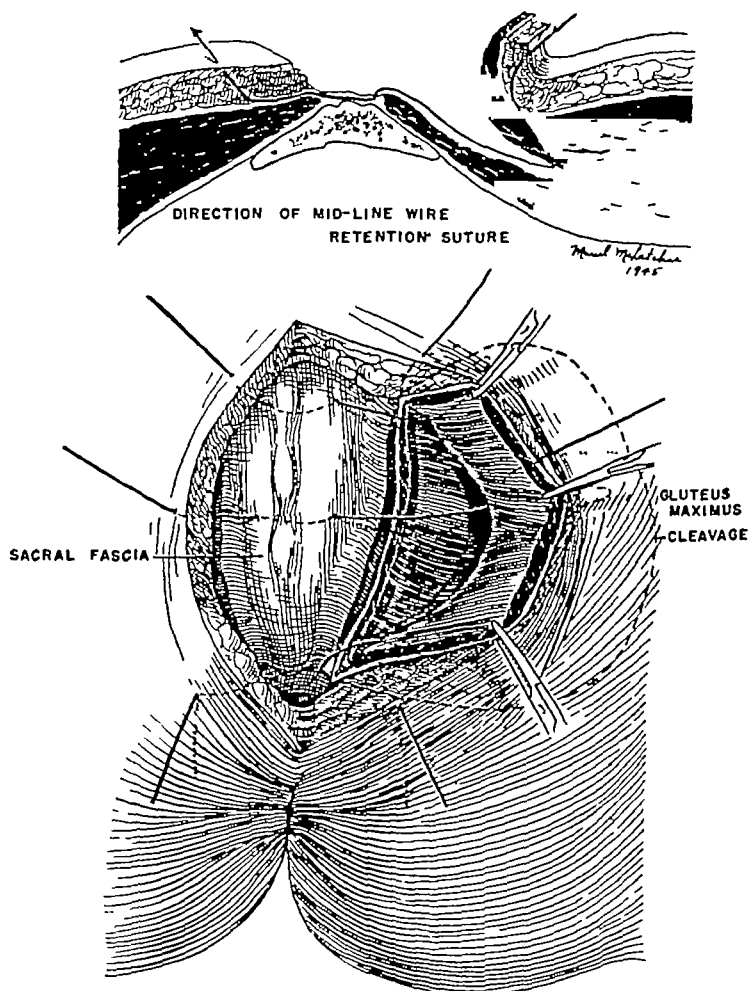


Fig 2—Semischematic illustration of a gluteus maximus cleavage and the insertion of midline wire retention sutures

to remain. Since bleeding usually stops in a minute or so, it facilitates the procedure to ignore it until the cleavage mobilization is completed and then, and only then, to suture with plain 00 surgical gut. Lateral muscle incision, formerly used instead of cleavage, causes bleeding which is difficult to secure in the depths of the muscle tissue and should be avoided. The usual spontaneous cessation of muscle bleeding when

incision and lateral cleavage are done correctly is spectacular in view of the preceding profuse flow

The operator will be both pleased and somewhat amazed at the easy closure now possible to effect. It is possible not only to cover the whole sacral and coccygeal area with a firm sliding layer of muscle tissue, with its overlying skin and fat, but also to make the closure supple and free from tension. Sulfanilamide is now frosted in the wound and gently mixed throughout. Excepting for the skin and its sub-

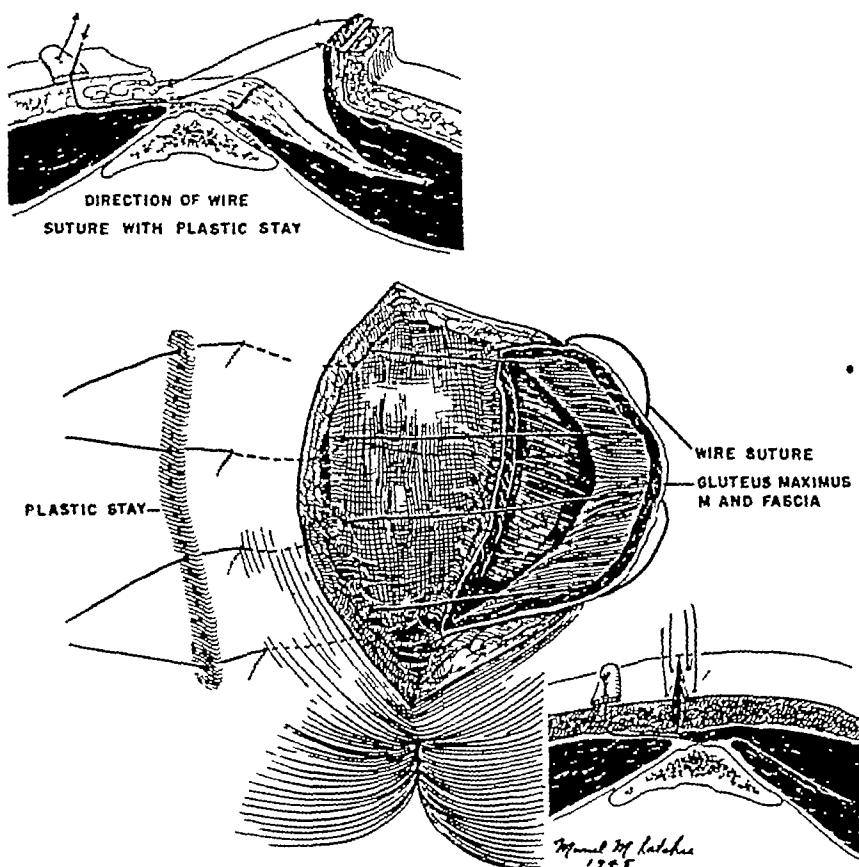


Fig 3—Semischematic illustration of the insertion of wire mattress sutures to a sliding gluteus maximus graft and illustration of a completed supple closure.

cutaneous layer of fat, closure is effected solely by wire suture. Two sets of wire sutures are used.

Three wire retention sutures and occasionally, in long wounds, a fourth are used to secure a moderate anterior-posterior pressure in the midline wound. These, equidistantly placed, carry through skin and fat from either side and carry through sacral fascia in the midportion of the wound. The lowermost of these wire sutures in the lower pole of the wound catches skin and fat but, being below the coccyx and its

fascia as well as the gluteus muscle, carries through the bottom layer of wound sulcus, close to the posterior wall of the rectum. On the side where muscle cleavage has occurred, it is necessary that the suture carry laterally through subcutaneous fat to enter the mobilized muscle layer at its point of most lateral cleavage or else, on tying and tension, an inadequate covering of muscle will result across the base of the sacrococcygeal fascia. These wires are tied over five or six layers of folded gauze in the midline. To avoid undue tension and pressure, a three-fourths length tongue depressor placed lengthwise in the gauze distributes pressure on the sutured skin over the flat surface of the posterior sacrum.

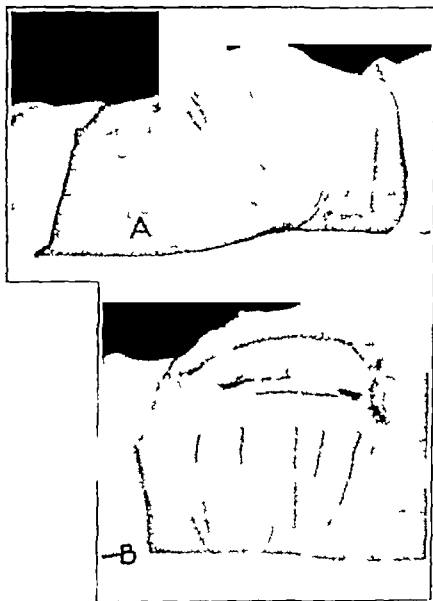


Fig 4—A, pilonidal sinus, with adhesive dressing. B, pilonidal sinus, with the dressing exposed.

The other set of wire sutures carries through the mobilized muscle and its fascia close to its edge. The ends of each mattress suture carry to the base of the opposite intact gluteus muscle to carry out beyond the first set of sutures through subcutaneous fat and skin.

I devised a plastic lucite stay, molded to conform to the average outer curve of the buttocks, through which these wires insert and tie. These measure $\frac{3}{4}$ inch (2 cm) in width and 5 inches (12.7 cm) in length and are smooth and rounded, with a slight bend at the ends so as to fit smoothly and not dig into the skin. Holes, bored about wire size, are placed $\frac{1}{4}$ inch (0.6 cm) apart in the midline throughout their length. Two mattress sutures, with the four wire ends placed evenly on this plastic lucite stay, work excellently and

prevent trouble experienced before in undue cutaneous pressure, blistering or necrosis. Care must be taken, of course, that undue tension does not occur in tying.

The skin is closed with no. 10 silk, a deep vertical mattress suture being taken. In addition, it is important to use interrupted skin sutures as well, so no shift of skin can later occur.

The dressing is mounded slightly, an A B D pad is cut to cover the wound neatly and an adhesive moderate pressure bandaging is applied. It is important that these strips be carried over the anterior iliac crests and that the buttocks be carefully and smoothly bound for



Fig. 5—Pilonidal sinus, showing a healed operative wound

protection of wounds, pressure on wounds and partial immobilization of the muscle.

No subsequent dressings are necessary until the eighth day, when the wire sutures are removed with care. The skin sutures are removed on the tenth postoperative day. Continued adhesive binding of the wound is preferable to prevent undue strain and trauma until the fifteenth or sixteenth day. After the tenth day, gradually increased activity is permitted.

Though I have formerly used a bilateral gluteus maximus cleavage in a fair series of operations, only two were done in this series of ninety-two, and these were not necessary. Either side may be used, regardless of the pathologic changes present. In this series eighty-

three cleavages were of the right gluteus maximus muscle, mainly because it was more convenient when operating on the left side of the patient to do so. In 7 cases cleavages of the left gluteus maximus muscle were used.

It should be mentioned that a slight sensory numbness of tissue may be experienced for a few weeks in some cases. This gradually disappears. Care, of course, must be taken not to cut down onto the bony part of the sacrum but, as described, to leave a small cuff of muscle tissue along its lateral border.

This operation was also found applicable in certain orthopedic cases, and a paper describing its use in such instances is now in the process of publication.

CONCLUSIONS

1 A new and successful operation for pilonidal sinus is described. Block excision is done. A sliding muscle graft is obtained by gluteus maximus cleavage mobilization. This permits supple closure of all tissues and freedom from tension on tissues.

2 The operation has further merits in that it adequately fills all dead tissue space with muscle substance, is conducive of rapid healing, offers an excellent protective pad of tissue and is performed with ease.

3 The operation follows sound principles of surgical treatment.

4 In a series of one hundred and thirty closed operations, ninety-two gluteus maximus sliding grafts were successfully performed. The remaining thirty-eight simple closure operations served as a control series. The results of this series and a detailed regimen for their management are described in an accompanying paper. The results of this series further substantiate its claims for adoption.

5 The operation is applicable in all cases of pilonidal sinus excepting those in which involvement of the spine or bones is shown. The technic used in extensive involvement is described.

6 The operation is applicable to certain orthopedic problems.

Evanston, Ill

ANAPHYLAXIS-LIKE REACTIONS PRODUCED BY ASCARIS EXTRACTS

II The Mechanism of the Shock Induced in Dogs

M ROCHA e SILVA and A GRAÑA
SAO PAULO, BRAZIL

IT is a well known fact that leukopenia and thrombopenia regularly accompany anaphylactic shock in every species of animals¹ In 1924 Webb² made an extensive study of the leukopenia which occurs in sensitized dogs as a consequence of the injection of the antigen Recently, Kopeloff and associates³ and Kinsell and co-workers⁴ have shown that a decrease in platelets is definitely proportionate to the gravity of the anaphylactic shock in monkeys and rabbits They have also postulated that a rupture of those hematologic elements might help to explain the liberation of histamine, since rabbit platelets are especially rich in histamine⁵ In the case of dogs, however, it is not so easy to explain the increase of histamine in the blood as a consequence of an explosion of platelets, since those elements are very poor carriers of histamine in this species of animal Moreover, it has been proved that most of the histamine which appears in the circulating blood during anaphylactic shock in dogs comes from the liver This organ loses considerable amounts of histamine after in vivo anaphylactic shock, as shown by Dragstedt and associates⁶ Drastic reductions in total liver histamine in the anaphylaxis-like reaction produced by ascaris extracts were also shown in the preceding paper⁷

From the Department of Biochemistry and Pharmacodynamics, Instituto Biologico

1 Achard, C, and Aynaud, M Compt rend Soc. de biol 67 83, 1909
Behring, E., cited by Quick, A The Hemorrhagic Diseases, Springfield, Ill, Charles C Thomas, Publisher, 1942 Pardi, U Arch ital de biol 64 89, 1915
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4 Kinsell, L. W, Kopeloff, L M, Zwemer, R L, and Kopeloff, N
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6 Ojers, G, Holmes, C A, and Dragstedt, C A J Pharmacol & Exper
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7 Rocha e Silva, M, and Graña, A Anaphylaxis-Like Reactions Produced by
Ascaris Extracts I The Changes in the Histamine Content and the Coagulability
of the Blood in Guinea Pigs and in Dogs, Arch Surg 52 523 (May) 1946

There is another common occurrence in anaphylactic shock in every species of animal that merits consideration when one is dealing with the mechanism of the shock—the explosive liberation of heparin from cells to plasma. The discharges of heparin and histamine are so intimately correlated that one is induced to attribute both phenomena to a single working factor.

That a rapid disappearance of leukocytes and platelets from the circulation is not enough to explain shock is shown by the fact that liver glycogen is very effective in producing drastic reductions in leukocyte and platelet counts without any sign of circulatory impairment, as shown in this paper concerning dogs and in a separate paper concerning rabbits.⁸ The final solution of the problem of anaphylaxis will probably be found in a recognition of the relative and specific importance of each one of the phenomena previously mentioned, as suggested by the experiments presented in the following paragraphs.

In the present paper we aim to analyze further the anaphylaxis-like shock produced in dogs by the injection of extracts derived from *Ascaris lumbricoides*. The favorable condition which induces one to study more thoroughly this particular kind of shock is the fact that it develops with extreme severity in almost all the dogs submitted to the experiment, while severe anaphylactic shock induced by a previous preparation of the animal with foreign proteins occurs only in a relatively small percentage of animals (about 30 per cent). We have reasons to believe that the presence of a macromolecular glycogen-like substance in the ascaris extracts is the factor which aggravates the condition.

EXPERIMENTAL STUDIES

The preparation of the crude ascaris extracts used in the experiments to be presented was made according to the procedure described in the previous paper.⁷ Glycogen was prepared by grinding in a meat chopper the liver of a well fed dog. The mass of ground liver was treated with an equal volume of 10 per cent trichloroacetic acid solution and the mixture stirred for two hours at room temperature. After filtration, the opalescent filtrate was treated with an equal volume of ethyl alcohol and the precipitated glycogen material collected by centrifugation. The crude product was further purified by two or three redissolutions in isotonic solution of sodium chloride and reprecipitations with 50 per cent ethyl alcohol. For injection, the glycogen was dissolved in isotonic solution of sodium chloride in the proportion of 1 Gm per 3 cc of saline solution.

The trypsin used in the experiments of liver perfusion was an active crystalline material from Lehn and Fink Laboratories.⁹

For recording blood pressure of the carotid artery the animals were anesthetized with dial and morphine sulfate. The doses of anesthetics and the conditions of collecting samples of blood were the same as those in the previous paper.⁷

8 Rocha e Silva, M, and Graña, A. To be published.

9 This material was supplied through the Brazilian Engine Factory Offices in New York.

Usually, three samples were simultaneously taken one for estimation of histamine according to Code's method,¹⁰ one for determination of leukocytes and platelets and one to check on the coagulability of the blood

The experiments on perfusion of the liver were performed in the following way In an anesthetized dog, a cannula with a drain was inserted into the carotid artery, the abdomen was opened and the hepatic artery clamped, after complete exsanguination through the carotid artery drain, a cannula was quickly inserted into the trunk of the portal vein and 500 cc of warm isotonic solution of sodium chloride passed through the liver to remove all traces of blood, after ligation of the ramus to the portal vein distal to the cannula, the left and central lobes of the liver were tied off and excised, finally, the rest of the organ was freed from its connections with the diaphragm and abdominal organs and carefully transferred to an appropriate heated funnel, while the perfusion with Tyrode solution or defibrinated blood started The collected perfusates, flowing at a rate of 10 to 12 cc per minute were tested every four to five minutes on a fragment of guinea pig ileum, sensitive to 0.02 microgram of histamine

RESULTS

Experimental Perfusion of Liver with Ascaris Extracts, Horse Serum, Trypsin and Mercury Bichloride—As shown in the preceding paper,⁷ the injection of a potent ascaris extract into the veins of normal dogs produces an enormous engorgement of the liver, with stasis in the portal region and discharge of histamine into the general circulation That this histamine which appears in large amounts in the circulating blood comes from the liver cells was definitely shown by the fact that there is a considerable decrease in total histamine extractable from pieces of liver taken after shock On the other hand, the increases in blood histamine are usually much more conspicuous when the samples are taken directly from the portal vein The analogy with what occurs in true anaphylactic shock is manifest Ojers, Holmes and Dragstedt⁶ have shown that liver histamine decreases after shock and that there is a close correspondence between this decrease and the gravity of shock In the case of the shock produced by ascaris extracts, this proportionality was not verified in every instance, since in a small number of animals the shock was not accompanied with much discharge of histamine or heparin into the circulating blood, and yet the blood pressure fell rapidly to zero But in most of the animals the liver histamine was reduced to one half or one third of the initial value This would mean a release of milligrams of histamine from the total organ or at least of many hundreds of milligrams of histamine base from pieces of liver weighing 100 to 200 Gm In order to ascertain whether this release of histamine was the consequence of a direct action of the ascaris extracts on liver cells or another mechanism was involved in the production of the phenomenon, we submitted the livers of 7 dogs to the perfusion

¹⁰ Code, C F J Physiol 89 257, 1937

with Tyrode solution or defibrinated blood. Usually, only a half or a third of the total mass of the liver was submitted to perfusion. As a rule, after the experiment with the ascaris extract, the conditions of the perfusion were checked by injection of either crystalline trypsin or mercury bichloride. Chart 1 shows the results obtained in the per-

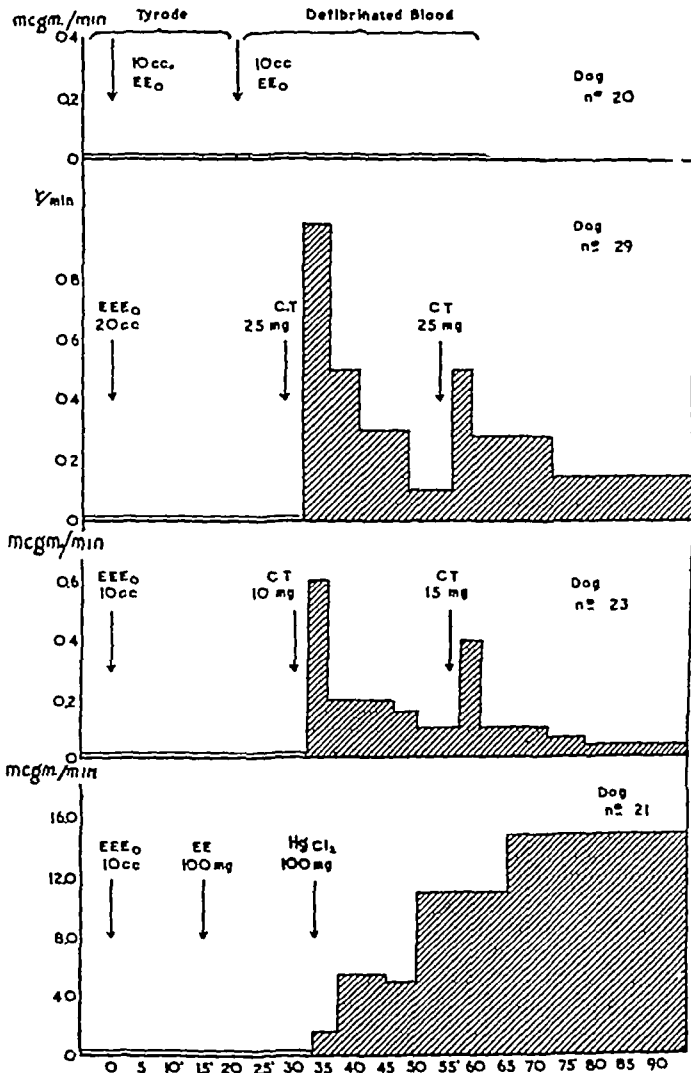


Chart 1—The graphs show the course of experiments of liver perfusion performed in 4 dogs. As seen, the injection of 10 to 20 cc. of a potent ascaris material (EEE₀) or a highly purified material (EE₁) is unable to liberate histamine from liver cells. The injection of 10 to 25 mg of crystalline trypsin or 100 mg of mercury bichloride was regularly followed by a copious release of active free histamine. Dog 29 was hypersensitive to ascaris extract, by a previous injection of the material.

fusion of the livers of 4 dogs, 1 of which had been previously sensitized to ascaris extract by two subcutaneous injections of the material.

twenty days before the experiment. It would be expected that this animal should be hypersensitive to the effects of ascaris extracts.

In most of the dogs the extract was injected directly into the cannula connected with the portal vein, but in some dogs it was injected far away from the cannula to permit a dilution of the extract and, consequently, a longer contact of it with the liver cells. In no case did ascaris extract produce any detectable release of histamine from isolated liver of dogs. It is interesting to recall that the fragment of guinea pig ileum used for assaying the perfusates was sensitive to hundredths of a microgram of histamine and that amounts at least one hundred thousand times greater would be expected to be released from the fragments of the liver submitted to the perfusion by calculating from *in vivo* experiments. To exclude the possibility that ascaris extracts might liberate an inactive compound of histamine with some cell constituents in several instances, the perfusates were submitted to Code's method of extraction with entirely negative results. Furthermore, pieces of the isolated liver were taken before and after the injection of ascaris extracts into the perfusing cannula and there was no indication of a decrease in the histamine which can be extracted from the organ. As the effect on the liver in the intact dog might depend on products derived from the abdominal organs, we perfused the whole mass of abdominal viscera of 1 dog. A cannula was tied into the trunk of the thoracic aorta and the perfusate collected from the inferior vena cava, just above the diaphragm. After washing out the blood, perfusion with Tyrode's solution was started, and 20 cc of a very potent ascaris extract was injected into the arterial cannula. Even in this case, there was no release of detectable amounts of histamine.

Two of the animals used had been previously sensitized to horse serum. Before injecting the ascaris extract, 20 cc of horse serum was injected into the portal cannula. No histamine appeared in the perfusates after thirty minutes of experiment.

From those experiments we can conclude that dogs' liver does not yield histamine by *in vitro* anaphylaxis or after the injection of an agent which produces severe anaphylaxis-like reaction in the intact dog. This means that the direct contact of the antigen with the sensitized liver cells is not enough to discharge the histamine. It is interesting to recall that in 1917 Weil¹¹ was unable to obtain any evidence of the release of an anticoagulant (heparin) following direct perfusion of the liver of sensitized dogs with Locke's solution plus antigen. Furthermore, all indications of a release of an anaphylatoxin from dogs' liver were given when sensitized liver was inserted into

¹¹ Weil, R. J. *Immunol* 2:525, 1917.

the circulation of a normal animal, as shown in the experiments of Manwaring and associates¹² So far, there has been no indication in literature of a release of an active histamine-like substance from the isolated sensitized dogs' liver after the injection of the antigen

The only effect so far observed in dogs' liver in experiments of perfusion with the antigen has been the moderate reduction of perfusion flow, as observed by Mautner and Pick¹³ In our experiments with ascaris extracts and horse serum, the decrease in the volume of perfusate in five minutes was slight but detectable In 1 experiment, for instance, the volume of perfusate dropped from 83 cc in five minutes to 65 cc after the injection of 20 cc of ascaris extract into the portal cannula Five minutes later, however, the volume returned to 80 cc A much more striking reduction in the perfusion flow was observed after the injection of trypsin In 1 experiment, the volume of flow varied from 80 cc in five minutes to 48 and 38 cc and went up again to 60 cc within twelve minutes after the injection of trypsin A new injection of trypsin produced a new diminution of flow to 50 cc in five minutes and a prompter return to normal

Mechanical Shock—Contrasting with the type of shock occurring in most of the animals given the ascaris extracts intravenously, there is a kind of shock produced by ascaris extract, with practically no changes in the histamine content or in the coagulability of the blood This was clearly seen in dog 31 Although the blood pressure went down and the animal died thirty minutes after the injection of ascaris extract without showing any sign of recovery, the blood histamine was low in the normal range, and the coagulability of the blood was altered only in the later stages of the shock All the morphologic characteristics of very severe shock were present The liver was enormously engorged with blood and definitely dark or black, the turgescence in the portal vein was maximal, and yet there was no increase in the histamine content of either the femoral or the portal vein The leukocytes went down from an initial value of 11,600 to 5,800 six minutes after the injection of 15 cc of the crude ascaris extract The samples of blood collected one, three, six and eight minutes after the injection of the ascaris extract clotted in two, fifteen, thirty and thirty minutes respectively The samples collected seventeen to thirty minutes after injection of the ascaris extract did not clot in twenty-four hours, indicating a late release of an anticoagulant The blood histamine, however, was low even in those samples which did not clot

12 Manwaring, W H , Hosepian, V M , O'Neill, F J , and Mov, H B
J Immunol **10** 575, 1925

13 Mautner, H , and Pick, E P Biochem Ztschr **127** 72, 1922

This picture of severe shock, with only a moderate release of histamine and heparin, has been tentatively named "mechanical shock" and seems to be the commonest kind of shock observed with hydatid fluid, as shown in a previous paper⁸ In his studies on blood histamine in anaphylactic shock, Code¹⁴ stated that in a few dogs the increases in blood histamine were not enough to explain death, since the animals died even after the blood histamine returned to normal On the basis of the findings in a few animals into which ascaris extracts had been injected we are now inclined to assume that there is a component of the anaphylactic shock in dogs that strongly suggests a mechanical obstruction of the portal circulation without much release

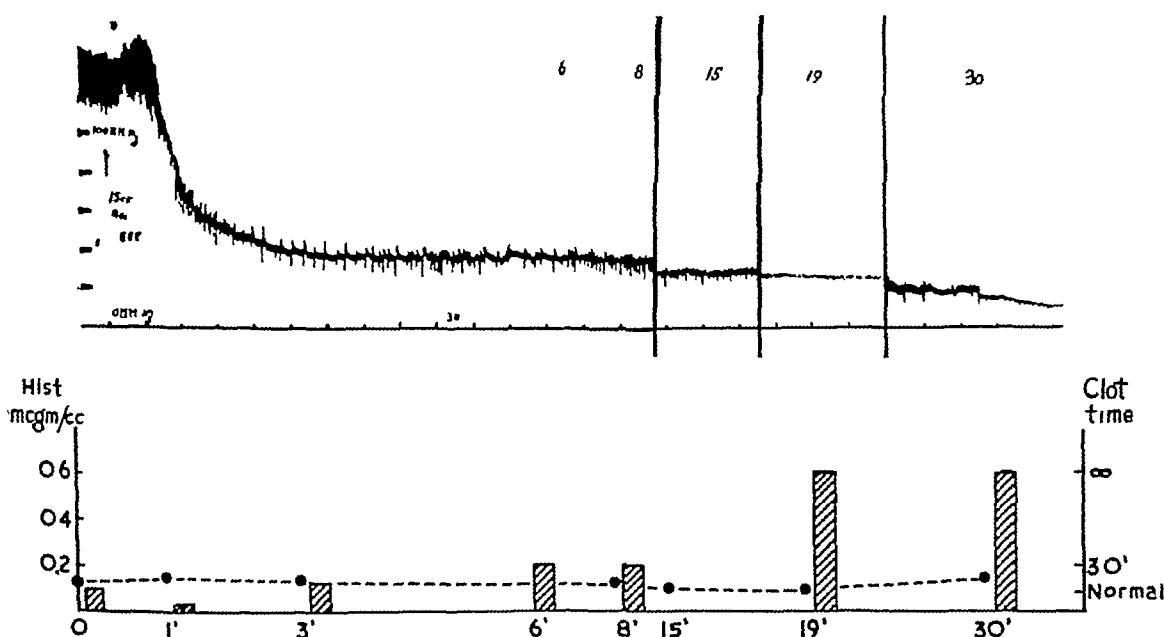


Chart 2 (dog 31) —After the injection of 15 cc. of a very potent ascaris extract, an extremely severe shock developed in the animal, without changes in the histamine of blood samples taken in the femoral and portal veins. The incoagulability of the blood became extreme only within nineteen minutes after the injection.

of active substances like histamine and heparin. We estimate that in 1 of 20 animals into which ascaris extracts are injected this sort of mechanical shock develops. It is logical to conclude, therefore, that even when there is a release of active substances the "mechanical" component is also present and that this anaphylaxis-like reaction produced by ascaris extract in dogs results from the superposition of those two kinds of shock, being only a question of degree if in 1 animal the "chemical" component is more pronounced than the

"mechanical" one or vice versa. We have many reasons to believe that this dual mechanism might explain many details of true anaphylactic shock produced by the reinjection of horse serum in dogs.

On the probable mechanism of production of this obstruction in the circulation in the liver we can hypothesize that a clumping of leukocytes and platelets, as shown to occur in anaphylactic shock,⁸ might be the working mechanism. For a reason not yet understood, there is no explosion of platelets and the chain of events leading to the liberation of histamine and heparin is broken somewhere and the process discontinued.

Inhibitory Effect of Glycogen on the Release of Histamine and Heparin During Shock—As shown in the preceding material, ascaris is unable to liberate histamine from isolated dog liver perfused with Tyrode solution or defibrinated blood. This would induce one to conclude that some of the components of the blood are indispensable for the *in vivo* release of histamine from liver cells as shown in the preceding paper.⁷ Our attention was primarily directed toward leukocytes and platelets as being the probable elements indispensable for the *in vivo* release of histamine from liver cells, since leukocytes and thrombopenia are inevitable occurrences during anaphylactic shock. It became necessary to find a suitable reagent to remove one or both of these elements from blood. Fortunately, we have been studying the effects of liver glycogen on rabbits' blood and observed that this substance practically removed platelets from circulating blood. Besides that, glycogen produces a sharp reduction in the leukocyte count, as observed first by Staub and associates¹⁵ and later confirmed by us.⁸

Thus glycogen appeared to constitute the appropriate reagent for a study of the role played by the hematologic elements in the production of a release of histamine and heparin from liver cells during anaphylactic shock. Injected a few minutes before, glycogen partially or totally desensitized the animals to a subsequent injection of the ascaris extract. The fall of blood pressure in the carotid artery was definitely reduced (charts 3 and 4) and the shock which occurred never had the extreme severity of the shock usually produced by ascaris extract alone. In most of the cases, the fall of carotid blood pressure was reversible and recovery followed promptly. A second injection of the same extract was practically without effect. Moreover, the drop in blood pressure was not so sharp, and usually a slow decrease occurred without much impairment in the heart beat and respiratory movements. Contrasted with the enormous engorgement of the liver occurring in almost all animals given injections of ascaris extracts alone, the organ usually retained its red-brown appearance when 3 to 8 Gm. of liver glycogen was

15 Staub, H., Mezev, K., and Golandas, G. *Klin. Wchnschr.* **17** 1501, 1938.

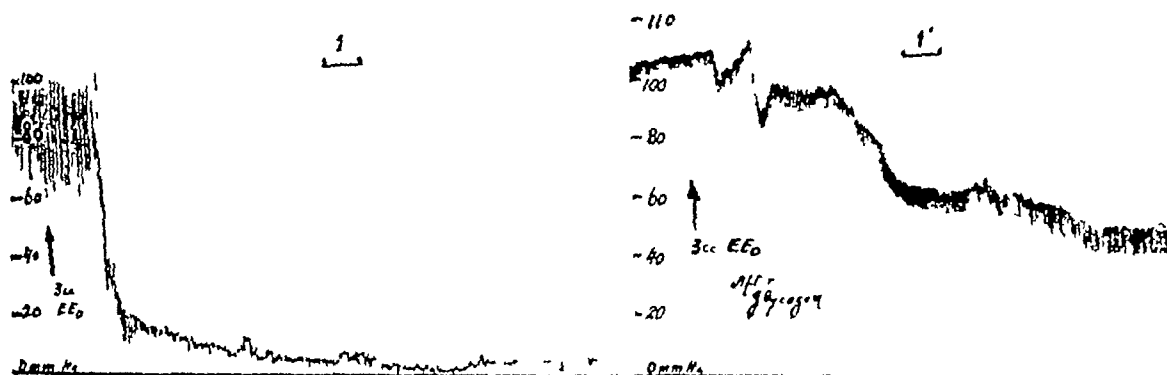


Chart 3 (dogs 41 and 40) —Modification of the intensity of the shock produced by ascaris extract following a previous injection of 8 Gm of glycogen. At the left, ascaris extract was injected alone, at the right, the extract was injected a few minutes after the injection of glycogen. Femoral artery tracings

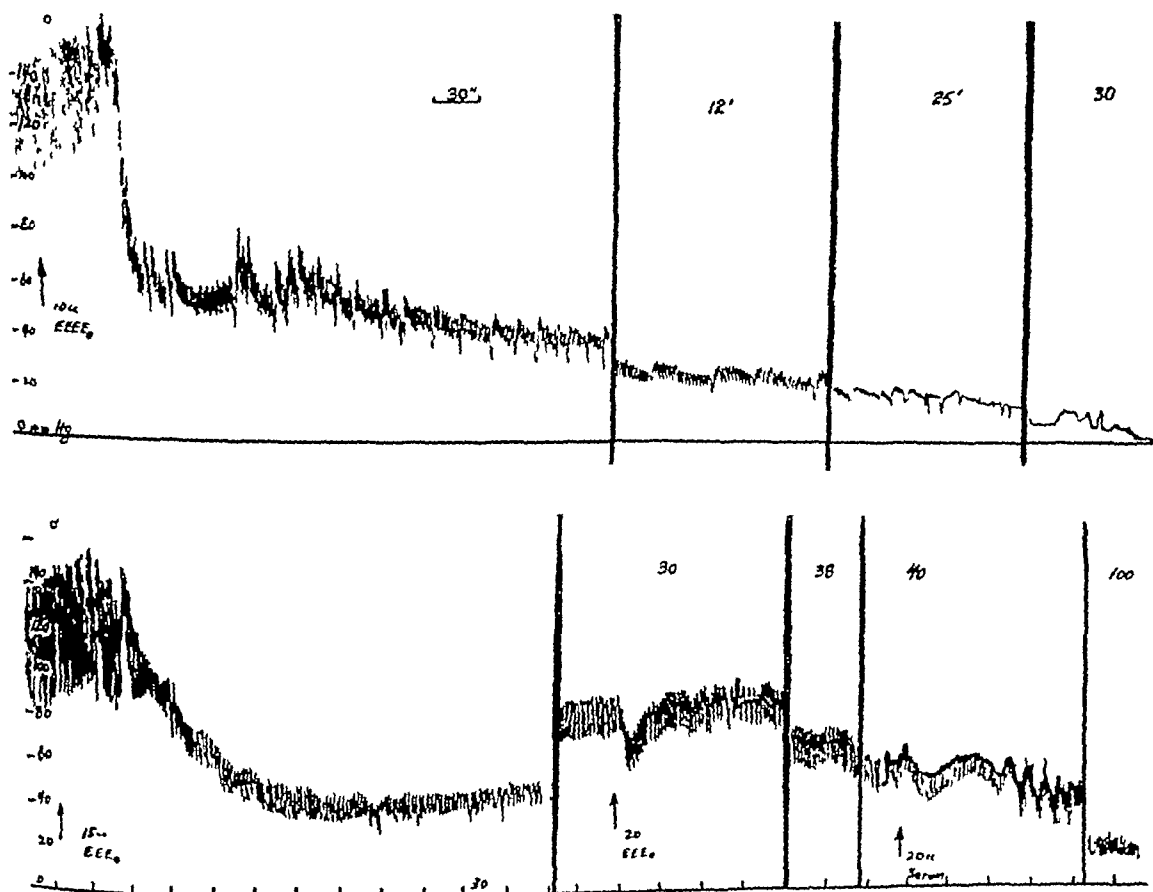


Chart 4—Upper tracing Dog 33 received 10 cc of an ascaris extract, the blood histamine went up to a level of 15 microgram per 1 cc, and the incoagulability of the blood was extreme. Lower tracing Dog 28 received 15 cc of ascaris extract, five minutes after the injection of 6 Gm. of liver glycogen, the blood histamine went down, and the blood clotted normally. This animal was sensitized to horse serum. As seen, an injection of 20 cc of horse serum did not influence blood pressure. The animal died in secondary shock one hundred minutes later.

injected before the ascaris extract. In a few animals, however, when greater volumes of ascaris material were injected a severer type of shock occurred, even when the animal was prepared by a previous injection of glycogen. The remarkable fact observed was that the blood histamine did not increase when the ascaris extract was injected after a suitable dose of glycogen. The incoagulability of the blood also

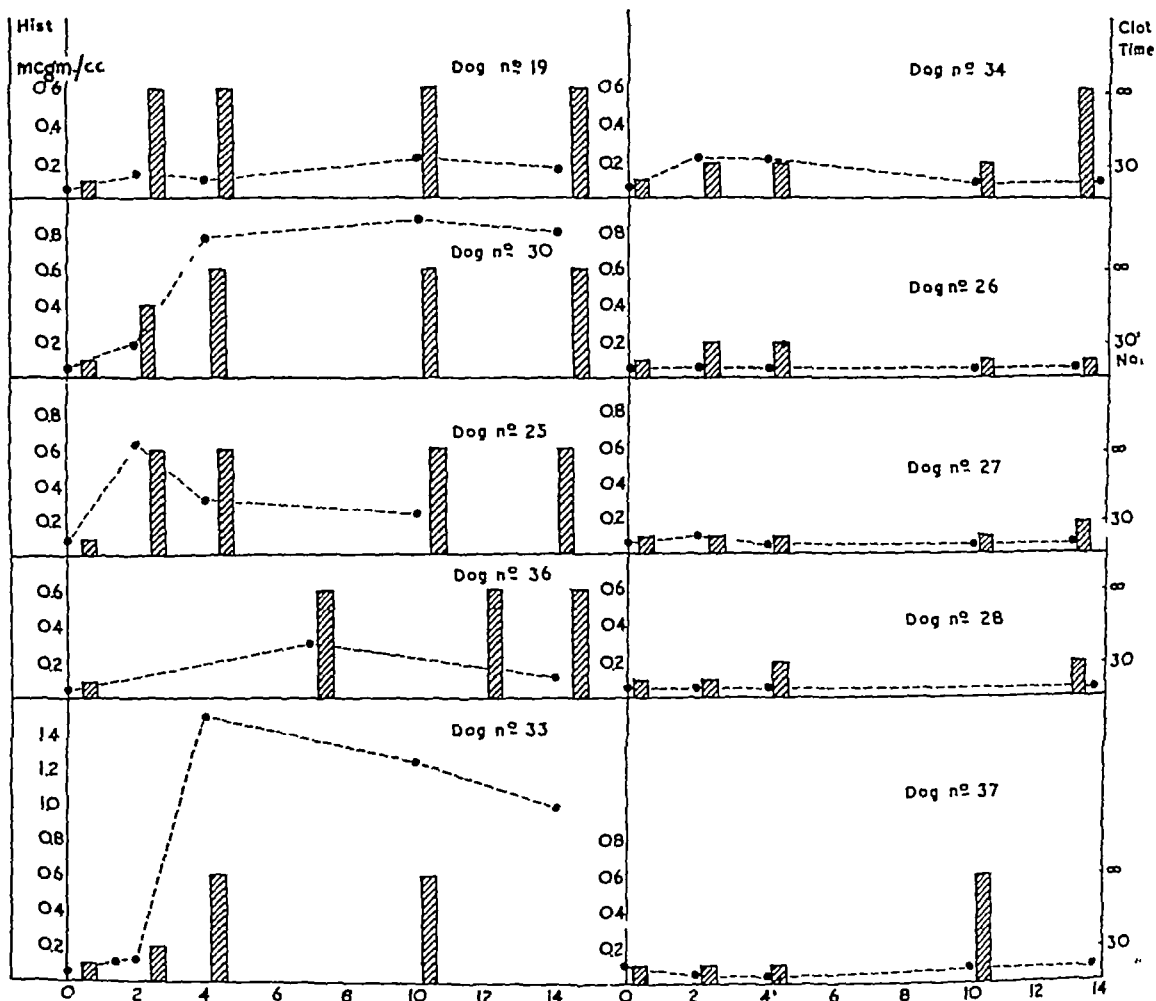


Chart 5—Inhibitory effect of glycogen on the release of histamine and heparin in 5 dogs (at the right) which received ascaris extracts after a previous injection of 3 to 8 Gm of glycogen. In the 5 animals at the left, ascaris extract was injected alone. Pointed lines represent blood histamine, and the rods, the degree of blood incoagulability.

was very slight, and only exceptionally did the blood become incoagulable. Even in the cases in which there was a significant fall of blood pressure, the blood histamine remained normal or below the norm.

while the coagulability of the blood was altered very slightly. The graphs presented in chart 5 show the results of the experiments performed on 10 dogs, 5 of which (at the left) received ascaris extract alone while 5 others (at the right) received 3 to 8 Gm of glycogen, two to five minutes before the extract was injected. It is apparent that glycogen almost entirely prevented the liberation of histamine or heparin.

In another sense this partial desensitization produced by glycogen might be of interest. It is generally agreed that desensitization to the antigen can be attained by means other than the immunologic exhaustion of antibodies (for a discussion of this point, see Dragstedt¹⁶). Peptone can desensitize dogs to a subsequent injection of the antigen. This might be partly due to a decrease of the mobilizable histamine of the liver, as suggested by Dragstedt, but we have now to consider that the desensitizing agent can also work on some of the components of the blood which are indispensable for the release of histamine and heparin from the liver cells. Glycogen appears to desensitize by dispersing platelets and leukocytes, and the same mechanism might hold true to explain unspecific desensitization to the antigen produced by several agents in sensitized animals.

Effects of Ascaris Extract and Glycogen on Leukocytes and Platelets—In the preceding section it became clear that a previous injection of glycogen partially or totally removed from blood the component which is responsible for the release of histamine and heparin. This definitely reduced the severity of the shock, and in 2 dogs it entirely prevented the drop in systemic blood pressure. In a few dogs, however, the shock was moderately severe, especially when large amounts of ascaris extracts were injected, with a definite drop in blood pressure, but even in those dogs there was no change in the histamine content of the blood. This allows one to assume that glycogen entirely desensitizes the animal for the "chemical" type of shock while only partially desensitizing it for the "mechanical" type of shock. As glycogen produces a partial removal of leukocytes, as shown by Staub and associates,¹⁵ and drastic reduction in the blood platelets, which fall almost to zero, as shown in the following material, one is warranted in concluding that the hematologic elements which are responsible for the release of histamine and heparin are the platelets, while the component responsible for the mechanical obstruction of capillaries and venules of the liver is the leukocytes plus platelets. This is further suggested by the results presented in the table, in which the leukocytes are recorded as estimated before and after the injection of glycogen and ascaris extract.

16 Dragstedt, C. A. J. Immunol. **47** 1 1943

As can be seen, in many cases the drop in the leukocyte count was not extreme after the injection of glycogen. After the injection of the ascaris extract, a further decrease could be seen, and in some instances this decrease was very important

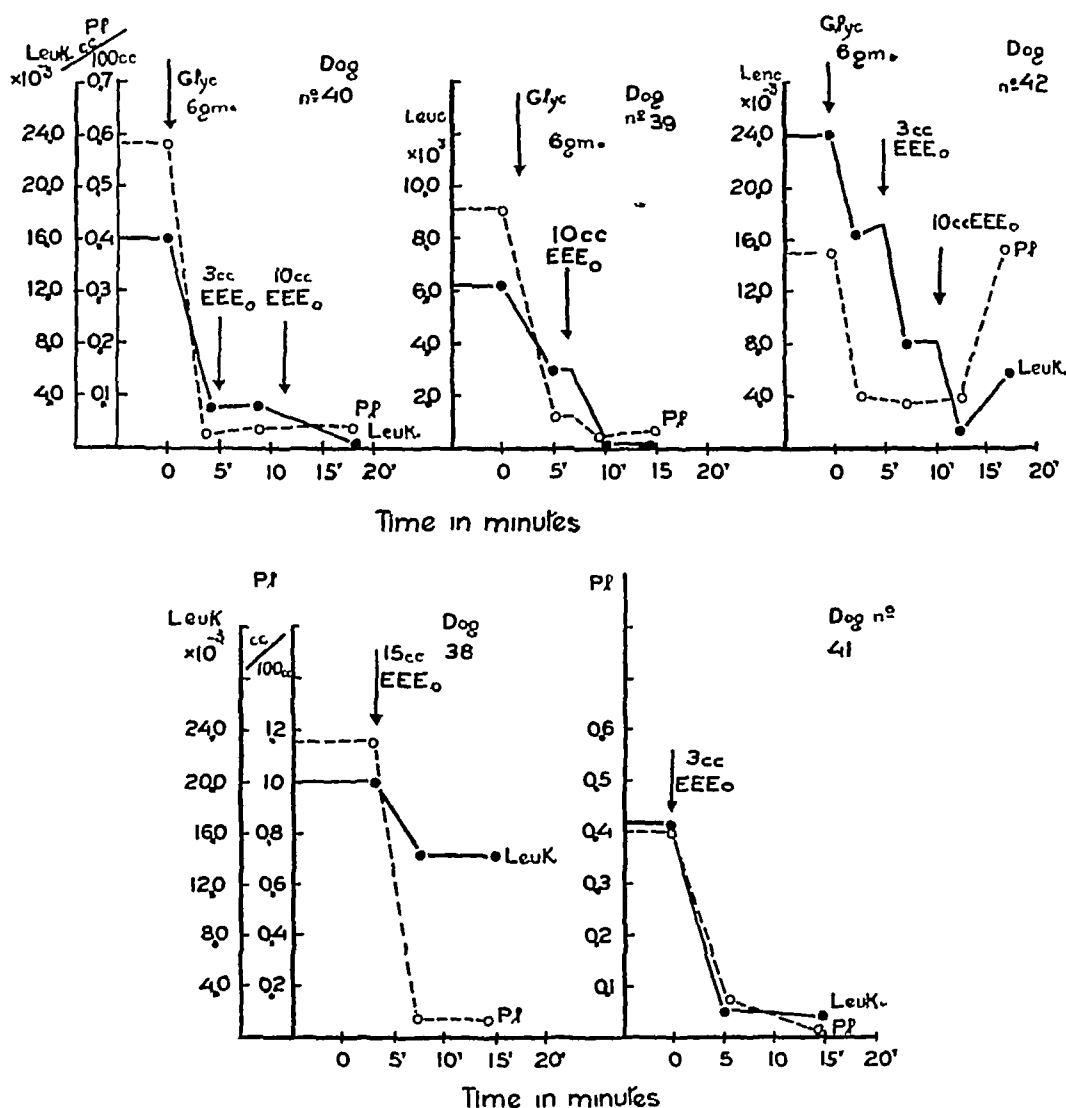


Chart 6—Effects of glycogen and ascaris extracts on the leukocyte count and the platelet volume in 5 dogs. As seen, glycogen injected before ascaris extract almost completely removes platelets from circulating blood, in such a way that there is no further decrease following the injection of the ascaris extract.

In every case, however, the exclusion of blood platelets was complete after the injection of glycogen, as indicated by Fomo's method. In 5 animals, the volume of platelets was estimated by use of a Van Allen thrombocytocrit, and at the same time, leukocyte counts were made

by the usual method¹⁷ As shown in chart 6, reductions in platelet volume per hundred cubic centimeters of blood were extreme after injection of glycogen or *Ascaris* extract alone If glycogen was injected before the *ascaris* extract there were no further variations in blood platelets after the injection of the *ascaris* extract The leukocyte curves followed the same trend, but the decrease in leukocytes after the injection of glycogen was not so extreme as the reductions in platelets, leaving a margin for the *ascaris* extract to further remove those components of the blood

Effect of Liver Glycogen and Ascaris Extracts on Total Leukocyte Counts

Dog	Weight Kg	Glycogen Injected, Gm	White Blood Cells, Thousands			Intensity of Shock
			Before Injection	After Glycogen	After <i>Ascaris</i> Extract	
30	5.5	0	41.0		8.0	++++
31	20.0	0	11.0		5.8	++++
33	10.0	0	14.2		8.6	++++
35	16.5	0	20.1		2.4	++++
36	15.0	0	11.3		1.6	++++
38	5.7	0	19.6		14.0	+++
41	7.0	0	14.0		1.5	++++
26	9.5	3.0	13.6	2.6	0.2	++
28	14.0	6.0	14.6	6.4	2.0	+
27	15.0	6.0	7.6	8.8	3.4	++
37	17.0	8.0	12.4	8.3	1.9	+++
39	4.7	6.0	6.2	3.0	0	++
40	5.0	6.0	16.0	3.2	3.0	+
42	6.5	6.0	24.0	16.8	5.6	±

COMMENT

The interesting result obtained in the experiments of perfusion of dogs' liver with Tyrode solution or defibrinated blood was that the *ascaris* extract is unable to liberate histamine when put directly into contact with the liver cells. Similar experiments with negative results were performed in sensitized dogs by perfusing the liver with the antigen (horse serum). This negative result is a paramount factor for an understanding of the mechanism of the anaphylactic shock in this species of animal. There remains no doubt that the histamine which appears *in vivo* in the circulating blood derives from liver parenchyma, since there is a pronounced decrease in the histamine extractable from pieces of liver taken before and after shock. On the other hand, the histamine content in the portal vein increases quickly

17 Drs W. O. Cruz and E. Martins, of the Oswaldo Cruz Institute, in Rio de Janeiro, Brazil, helped in the experiments with the Van Allen thrombocytocrit, which were performed in the hematologic laboratory of the Oswaldo Cruz Institute.

and attains levels which are much higher than those verified in the general circulation. This occurrence definitely indicates a powerful stagnation in the hepatic circulation, which can be directly perceived by the enormous increase in the volume of the liver during shock. To reconcile the negative findings of liver perfusion with the *in vivo* discharge of histamine and heparin from liver cells, one has to assume that some factor or factors existing in the intact blood are indispensable for the production of the anaphylactic shock. In a separate paper⁸ we have shown that glycogen derived from ascaris extract, a polysaccharide substance extracted from hydatid fluid and glycogen extracted from dogs' liver produce in rabbits a definite leukopenia and thrombopenia, this accounting for the drastic reduction in blood histamine which occurs in those circumstances. Staub and associates¹⁵ have made extensive studies on the leukopenia produced in dogs by macromolecular substances, like glycogen, starch and acacia, suggesting that the leukocytes which disappear from circulating blood will be retained in the capillaries of the lung and the skin. In our experiments, we have observed that glycogen also produces a thrombopenia but no changes in the arterial blood pressure. The leukopenia, however, is not so constant and depends on the anesthesia to which the animals have been submitted. When injected before the extract of ascaris, glycogen partially or totally desensitizes the dog against the ascaris material. Especially the incoagulability of the blood and the increase in blood histamine are powerfully reduced or inhibited when the injection of ascaris extract follows an injection of appropriate amounts of liver glycogen. This experiment can be properly interpreted by assuming that the previous injection of glycogen removes from blood some of the factors which contribute to the production of the shock. It is logical to conclude that glycogen exerts a dispersing effect on blood platelets in such a way that an accumulation of those hematologic elements in the liver never attains a concentration high enough to produce the explosive liberation of histamine and heparin in the case of their disintegration. Since ascaris extracts contain considerable amounts of a glycogen-like material, it seems probable that this substance has a great significance in aggravating the accumulation of platelets in the capillaries of the liver. We have to postulate, however, the interaction of an anaphylactic factor to localize in the liver the massive accumulation of blood platelets which otherwise would disperse all over the body. This factor might be the initial anaphylactic constriction of the hepatic veins, transforming the liver into a filter for the clumped elements of the blood. This initial constriction of the hepatic veins was seen *in vitro* by Mautner and Pick¹⁸ in experiments of liver perfusion and definitely appeared in our experiments with ascaris extracts, horse serum and trypsin.

On the basis of this possibility, one might foresee the occurrence of a severe shock, without much liberation of histamine and heparin from liver cells. This kind of "mechanical" shock would be produced by the localization in the liver of the microthrombi of platelets and leukocytes. The actual occurrence of this kind of shock was definitely suggested by the experiment with dog 31, which was given intravenously 15 cc of an extremely potent extract. The increase in blood histamine and the incoagulability of the blood were moderate, and yet the shock was extremely severe, with enormous engorgement of the liver and death in thirty minutes without any sign of recovery.

Finally, it seems indispensable to accept the interaction of another element from the blood or the liver cells to explain the discharge of histamine and heparin in the capillaries of the organ. It has been suggested by previous experiments that histamine is bound to cells forming a peptide bond which can be specifically ruptured by a trypsin ferment¹⁸. Furthermore, trypsin liberates active histamine and heparin, as shown before¹⁹ and confirmed in the present report. The activation of proteases to explain the liberation of histamine in anaphylactic shock was suggested by Feldberg,²⁰ Rocha e Silva²¹ and more recently by Dragstedt and Wells.²² It seems logical to assume that activated plasma trypsin might be the agent responsible for the release of histamine and heparin. In this connection, it is interesting to recall that Iyengar²³ has observed that platelets contain a kinase which can activate trypsin by rupturing its connections with the trypsin inhibitor existing in the blood.

Thus the theory of the mechanism of anaphylactic shock in the dog which emerges from those experiments would postulate that the phenomenon develops in three stages: 1. There is an initial anaphylactic constriction of the hepatic vessels, effective in transforming the capillaries of the liver into a filter, which otherwise would be capillaries of the lung and the skin. 2. The leukocytes and platelets agglutinated in contact with the anaphylactic agent (antigen) will form microthrombi in the small vessels and capillaries of the liver. 3. After the latent period the platelets would "explode" liberating an enzyme factor which would act directly on the liver parenchyma, liberating the histamine and heparin which are discharged into the portal and general circula-

18 Rocha e Silva, M., and Andrade, S. O. *J Biol Chem* **149** 9, 1943

19 Rocha e Silva, M. *Arch f exper Path u Pharmacol* **194** 335, 1940

20 Feldberg, W., and Luck, J. M. *Annual Review of Physiology*, Stanford University, Calif., Annual Reviews, Inc., 1941, vol 3, p 671

21 Rocha e Silva, M. *J Pharmacol & Exper Therap* **77** 198, 1943

22 Dragstedt, C. A., and Wells, J. A. *Quart Bull, Northwestern Univ. M School* **18** 104, 1944

23 Iyengar, N. K. *Indian J M Research* **30** 467, 1942

tion The proteolytic nature of the enzymes which are activated after the rupture of platelets is suggested by the fact that histamine and heparin appear to be released from cells by the action of a ferment of the nature of a tryptase

SUMMARY

Ascaris extracts, very active in producing an anaphylaxis-like reaction in the intact dog, are unable to produce a discharge of histamine from the isolated liver perfused with Tyrode solution or defibrinated blood Similar negative results were obtained by perfusing sensitized dogs' liver with the antigen (horse serum) In identical circumstances, trypsin and mercury bichloride produced a discharge of conspicuous amounts of histamine

A "mechanical" kind of shock in dogs following the injection of *ascaris* extracts is described This type of shock, which is characterized by profound fall in blood pressure of the carotid artery but no increase in blood histamine or heparin, occurs in about 5 per cent of the animals given injections of *ascaris* extracts and apparently depends on a mechanical obstruction of the hepatic vessels by clumped leukocytes and platelets, without very much discharge of active substances

Liver glycogen when given intravenously partially or totally desensitizes the animal toward the *ascaris* extract Especially the discharge of histamine and heparin from liver cells can be entirely prevented by glycogen

Liver glycogen almost entirely removes platelets from circulating blood and produces severe leukopenia Those effects provided the explanation for the inhibitory effect produced by glycogen on the release of histamine and heparin from cells of the liver by *ascaris* extracts

The implications of those facts for a better understanding of the mechanism of true anaphylactic shock are discussed

STRUMA LYMPHOMATOSA

A Clinicopathologic Study

BERNARD J FICARRA, M D

BROOKLYN

DISORDERS of the thyroid gland have fascinated surgeons since 1878, when Theodor Kocher first published his report of a successful thyroidectomy¹ Accentuated interest in this subject found an impetus in 1912, when Hashimoto described a new pathologic entity in the thyroid gland² Since he was the first to describe the lesion, it bears his name as well as the descriptive term "struma lymphomatosa"

This clinicopathologic entity is unusual because of its low incidence as well as its bizarre pathologic picture and symptom complex A study of the literature unfolds many discrepancies as to the exact number of cases reported since it was first described by Hashimoto In order to clarify this problem, Dr A Graham in 1931 studied the literature extensively³ He divided the reported cases into ten categories, interpreting and grouping them for statistical purposes His analysis clearly demonstrated the existing confusion, duplication and lack of proper identification in the various cases reported For this reason no accurate determination of the number of cases of struma lymphomatosa is possible However, up to the present time, various authors have reported small series of cases⁴ Thus it can be appreciated that this

From the Department of Surgery Kings County Hospital and Brooklyn Cancer Institute.

1 Kocher, T Exstirpation einer Struma retroesophagea, *Cor-Bis schweiz Aerzte* 8 702, 1878

2 Hashimoto, H Zur Kenntnis der lymphomatösen Veränderung der Schilddrüse (Struma lymphomatosa), *Arch f klin. Chir* 97 219, 1912

3 Graham, A Riedel's Struma in Contrast to Struma Lymphomatosa (Hashimoto), *West. J Surg* 39 681 (Sept) 1931

4 (a) McClintock, J C, and Wright, A. W Riedel's Struma and Struma Lymphomatosa (Hashimoto), *Ann Surg* 106 11 (July) 1937 (b) McSwain, B, and Moore, S W Struma Lymphomatosa, *Surg, Gynec & Obst.* 76 562 (May) 1943 (c) Joll, C A Pathology, Diagnosis and Treatment of Hashimoto's Disease (Struma Lymphomatosa), *Brit. J Surg* 27 351 (Oct) 1939 (d) Kearns, J E, Jr Struma Lymphomatosa, *Ann Surg* 112 421 (Sept.) 1940 (e) Scarcello, N S, and Goodale, R. H Struma Lymphomatosa, *New England J Med* 224 60 (Jan 9) 1941 (f) Jaffe, R H Chronic Thyroiditis, *J A M A* 108 105 (Jan 9) 1937, (g) Clute, H, Eckerson, E B, and Warene, S Clin-

(Footnote continued on next page)

entity is infrequently encountered during the professional career of the average surgeon

By a comparison of the occurrence of struma lymphomatosa in a consecutive series of thyroidectomies, the rarity of this disease can be evaluated. With this objective in view, I have studied the number of thyroidectomies and the number of pathologically proved instances of Hashimoto's disease which have occurred in the hospitals in Brooklyn listed in table 1

From the data available, it appears that only 5 cases of pathologically proved struma lymphomatosa were encountered over a period of five years at the hospitals listed in table 1. At one hospital (Jewish Hospital) the cases were reported as cases of thyroiditis and were not segregated according to types. However, from the present study it can be deduced that not more than 9 of these could be cases of struma

TABLE 1—*Thyroidectomies and Struma Lymphomatosa in Various Hospitals in Brooklyn*

Hospital	Years Studied	Number of Thyroid ectomies	Reported Cases of Struma Lymphomatosa
1 Brooklyn Hospital	1940-1944	215	1
2 Hospital of the Holy Family	1940-1944	160	3
3 Jewish Hospital	1940-1945	1,218	27 (reported as thyroiditis)
4 Kings County Hospital	1941-1945	345	1

lymphomatosa. During the same period, 1,938 thyroidectomies were performed. This statistical series definitely categorizes the disease among the rarities in surgery.

ETIOLOGY AND PATHOLOGY

The exact causation in the production of struma lymphomatosa is unknown. It has been suggested that exhaustive atrophy is a recognized change in Hashimoto's struma and that this degeneration might be associated with some form of compensatory hyperplasia resulting in this disease.^{4a} Graham's study has led him to express the opinion that there is no proof that hyperthyroidism, hypothyroidism, suppuration, tuberculosis, syphilis or neoplasm are factors in the causation. Although the exact nature of the condition has not been determined, the current belief is that Hashimoto's disease should not be included in the same category with Riedel's struma.³ Although frequently confused with Riedel's struma, many authors have concurred in the opinion that

ical Aspects of Struma Lymphomatosa, Arch Surg **31** 419 (Sept.) 1935 (*h*)
Schilling, J. A. Struma Lymphomatosa, Struma Fibrosa and Thyroiditis, Surg,
Gynec., & Obst. **81** 533 (Nov.) 1945

Riedel's struma and Hashimoto's disease are two distinct pathologic entities ^{4g}

Micropathologic study of this disease reveals a dense, diffuse, lymphoid infiltration between the follicles, with occasional formation of secondary nodules. Sometimes these follicles are extremely prominent, so that the microscopic picture may closely simulate a lymph node. Hence the terminology struma lymphomatosa or, as it is sometimes called, lymphomatoid goiter ^{4h}. There tends to be a variation in the intensity of the lymphocytic infiltration, from occasional scattered lymphocytes among colloid-containing follicles or even absence of infiltration in certain areas to complete displacement of the normal thyroid, with confluent masses of lymphocytes forming secondary nodules. Other types of cells found are monocytes and occasionally plasmacytes. Notwithstanding the abundance of lymphocytic infiltra-



Fig 1—Photomicrograph illustrating lymphocytic infiltration, with resulting distortion of the normal architecture of the thyroid gland, typifying struma lymphomatosa

tion, the lymphoid tissue does not demonstrate a tendency toward definite formation of lymph nodes. That is, there is no formation of struma or sinuses ^{4g}

The connective tissue is usually swollen and poorly stained, and the cells have few nuclei. Mononuclear lymphocytes may be readily identified in the connective tissue. In rare instances, the interlobular and intralobular connective tissue may be sufficiently increased to predominate over the lymphocytic infiltrations. When this occurs, small islands of follicles are enclosed in the connective tissue ⁵. It is areas of this

⁵ Boyd, W. Surgical Pathology, Philadelphia, W. B. Saunders Company, 1943

type which often lead to the erroneous belief that Hashimoto's disease is an early stage of Riedel's struma. Microscopic study of the blood vessels reveals no remarkable alteration in their normal architecture except for the fact that an abundance of round cell infiltration is noted around the larger vessels

Thus struma lymphomatosa is a lymphoid goiter characterized by a growth of lymphatic elements in the formation of lymphoid follicles together with certain changes both in the parenchyma and in the interstitial tissues of the thyroid gland

CLINICAL PICTURE

The disease occurs almost always in women. It has an insidious onset and follows a chronic course. The duration of symptoms may vary from nine months to five years or more. The clinical manifestations result from pressure of the hardened gland on the trachea. Usually there are no symptoms of a disturbed thyroid function in patients having the disease for a long period. When the disease is of a chronic nature, there is almost always an associated hypothyroidism at one time or another. The basal metabolic rate is usually within normal limits. On occasion, the basal metabolism may be below normal. Infrequently, evidence of mild myxedema may be noted.

A classical clinical history of struma lymphomatosa may be given as follows. The patient is a 40 year old woman who for many years' has had enlargement of the thyroid, which has grown rather slowly. She complains of weakness, fatigability, slight nervousness and some pressure symptoms. These pressure symptoms may be described as hoarseness, choking or dysphagia. On occasion a brassy cough or a roughening of the voice may be noted. The most satisfactory description of the gland in Hashimoto's disease has been provided by Dr. Richard B. Cattell, of the Lahey clinic. In order to palpate the gland adequately, the examiner should stand in front of the patient and turn the patient's head to the side to be examined. This will relax the sternocleidomastoid muscle. The examiner uses one hand to push the larynx toward the side to be examined. With the other hand, the thumb is pressed anterior to the sternocleidomastoid muscle and the second and third fingers are placed posterior to this muscle. The patient is then instructed to swallow. In so doing, the gland may be adequately palpated. In this way the length and breadth of the thyroid shield, the isthmus and the superior and inferior poles can be examined. The shape, size and consistency of the gland can thus be evaluated. When the lower pole is not felt, a roentgenogram of the trachea is indicated in order to determine tracheal deviation, substernal and subclavicular extension. The gland with Hashimoto's disease, when examined according to Dr. Cattell's method, will unfold the following diagnostic criteria

1 The gland has a diffuse pebbly feel 2 It feels as hard as exophthalmic goiter with involution of iodine 3 The superior poles are extremely broad, being broader than the poles of primary hyperthyroidism 4 The pyramidal lobe is enlarged similar to the enlargement of the lobe in primary hyperthyroidism

By seeking to determine the presence of these criteria, one can make the preoperative diagnosis of struma lymphomatosa with greater accuracy

DIAGNOSIS

The most valuable clinical aids in arriving at a diagnosis of struma lymphomatosa are to obtain an adequate history and to perform a satisfactory examination of the thyroid gland If the signs and symptoms parallel the clinical picture previously presented, a tentative diagnosis of struma lymphomatosa can be made

Struma lymphomatosa must be differentiated especially from other chronic infections and neoplasms of the thyroid gland The most confusing lesions are

- 1 Chronic nonspecific thyroiditis
- 2 Chronic specific thyroiditis
 - (a) Tuberculosis
 - (b) Syphilis
 - (c) Actinomycosis
- 3 Calcified adenomatous goiter
- 4 Lymphosarcoma
- 5 Carcinoma
- 6 Riedel's struma

Nonspecific thyroiditis is eliminated, since Hashimoto's disease displays the absence of inflammatory symptoms Hashimoto's disease is bilateral, may be associated with hypothyroidism and does not have a tendency toward spontaneous cure Specific granulomatous lesions are differentiated by the absence of any specific evidence of the causative organisms of tuberculosis, syphilis or actinomycosis The enlargement of the thyroid gland in specific infections usually produces a soft gland and does not possess the other physical characters of struma lymphomatosa Calcified adenomas, either solitary or multiple, are readily identified by calcific roentgenographic evidence of this type of degeneration

Struma lymphomatosa may be difficult to differentiate from neoplastic lesions However, it may be distinguished from malignant disease by the following points 1 In struma lymphomatosa all areas of the gland are involved, without serious encroachment on tissue outside the thyroid gland 2 Neoplasm involves all areas, including the main vessels and nerves 3 Struma lymphomatosa does not produce an irregular nodular

surface of the gland 4 Regional glandular enlargement due to metastases is absent in struma lymphomatosa and is usually prominent in neoplasms

Whenever a satisfactory differentiation between carcinoma of the thyroid and struma lymphomatosa is not possible, pathologic study of the operative specimen will decide the question

The present tendency among pathologists and surgeons is to regard struma lymphomatosa and Riedel's struma as distinct diseases⁶ Often these entities are difficult to differentiate from each other For this reason, table 2 is significantly valuable

In addition to the points given in table 2, Riedel's struma may be "frozen" in the neck It is the hardest pathologic entity (except a calci-

TABLE 2—*Differentiation of Hashimoto's Disease and Riedel's Struma*

Hashimoto's Disease	Riedel's Struma
1 It is practically always confined to women	Disease is reported equally in men and women
2 A history of myxedema may be obtained	There is little tendency toward myxedema, especially following operation
3 Glandular involvement is diffuse and bilateral	Involvement is usually unilateral, following a discrete nodule
4 Pressure symptoms are infrequent	Pressure symptoms, such as hoarseness, difficulty in swallowing and limitation of the cord on the involved side, are common
5 Periglandular adhesions are absent	Pronounced adhesions to adjacent structures are found
6 Pyramidal lobe is prominent	Pyramidal lobe is usually not prominent
7 Histologically fibrosis is circumscribed	Histologically fibrosis is diffuse
8 Lymphoid hyperplasia is pronounced	There is no lymphoid hyperplasia
9 There are no Dorothy Reed cells	Dorothy Reed cells can be identified

fied adenoma) felt in the neck It is hard as cartilage and cuts with difficulty Hence it has been called "iron struma" or "ligneous" or "woody thyroiditis"

TREATMENT

Operation in struma lymphomatosa is indicated for two reasons (1) to differentiate the lesion from cancer and (2) to relieve or prevent pressure symptoms At the time of operation the true identity of the pathologic change in the thyroid is revealed The gland with Hashimoto's disease is enlarged from two to five times the normal size It is not adherent to adjacent structures Thus it is immediately differentiated from cancer or Riedel's struma The gland is gray-pink and is firm When sectioned, it is white, with a suggestion of focal edema Compression of the gland with a clamp results in the extrusion of a serous fluid Clamps grasp the tissue poorly and hold fast only to the fibrous capsule and to the blood vessels in the gland parenchyma

6 McClintock and Wright^{4a} Clute, Eckerson and Wareen^{4g} Schilling^{4h}

Bleeding is not remarkable, because of compression and at times complete occlusion of blood vessels. This occlusion results from an increased fibrofollicular pressure, which is characteristic of Hashimoto's disease.

The surgical procedure is a routine subtotal thyroidectomy. However, the operation is less radical than that for primary hyperthyroidism. The remnants of the thyroid are sutured to the trachea in such a way that the midline of the trachea is free of thyroid tissue. By the prevention of contiguity of the remnants of the thyroid the possibility of future tracheal compression is avoided.

The postoperative course is usually uncomplicated. Brawny thickening of the cutaneous layers may occur, and it may persist for many weeks. In most instances myxedema can be anticipated. Patients should be advised of this possibility prior to operation. For this reason patients are followed postoperatively with routine determinations of the basal metabolic rate and the cholesterol level. Control of the myxedema is not difficult with a daily dose of thyroid extract. After operation these patients are much relieved, and they are perfectly well as soon as the myxedema is controlled. There have been no reported instances of recurrence of the disease following thyroidectomy. Operative mortality does not differ from the mortality in routine subtotal thyroidectomies.

PROGNOSIS

Untreated struma lymphomatosa may pass into myxedema. After thyroidectomy, complete and permanent relief of pressure symptoms results, although the onset of hypothyroidism may be accelerated. If this condition is anticipated, the postoperative administration of thyroid extract should be commenced as soon as incipient myxedema is suspected.

Postoperative recurrence is not usual. So-called recurrence can be attributed to inadequate surgical treatment. This occurs if the bilateral nature of the disease is not recognized and results in a unilateral resection which fails to relieve adequately the pressure symptoms. "It is a mistake to assume that the disease has in the interval merely spread from one lateral lobe to the other, for which view there is no reliable evidence. The explanation is most probably that in certain asymmetrical goiters (based on congenital asymmetry of the thyroid gland) one large lateral lobe may so overshadow the other small lobe that the latter is allowed to remain undisturbed." ^{4c}

SUMMARY AND CONCLUSION

Previous literary studies have indicated that Hashimoto's disease is listed among the rarer surgical entities. Our present study has corroborated this belief. Over a five year period, only 5 pathologically verified cases of struma lymphomatosa have been encountered in the

hospitals surveyed. At one hospital the cases were reported as thyroiditis. During this same period, 1,938 thyroidectomies were performed.

The salient feature of this disease is that its exact causation is unknown. It occurs almost entirely in women in the third, fourth and fifth decades of life. The fundamental pathologic change is a lymphocytic infiltration associated with follicular pressure atrophy. Vascular channels are obstructed because of fibrofollicular pressure. Clinically the most important findings are demonstrated by palpation of the thyroid gland. The features of struma lymphomatosa are broadening and enlargement of the superior poles and hard, firm lobes, giving the impression of a pebbly surface. Enlargement of the pyramidal lobe, as in hyperthyroidism, is notable. Pressure symptoms may or may not be present. Surgical treatment is indicated to relieve pressure symptoms and to differentiate the disease from neoplasm.

Little knowledge is present as to the course of untreated Hashimoto's disease, since patients in all the reported cases have been subjected to operation or radiation therapy. Thyroidectomy will relieve pressure and nervous symptoms. If postoperative myxedema occurs, it can be counteracted by the administration of thyroid extract.

CORRECTION

In the article by Dr. A. de Sousa Pereira entitled "A Basis for Sympathectomy for Cancer of the Cervix Uteri," in the March issue (*ARCH. SURG.* **52**: 260, 1946), the drawings in the upper right hand corner of figure 4 (page 267) and of figure 8 (page 271) are transposed.

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